EVALUATING THE IMPORTANCE OF FISHERIES TO US SECURITY AND THE OPPORTUNITIES FOR STRATEGIC INVESTMENTS IN AQUACULTURE TO STRENGTHEN THE US POSITION IN COMPETITION WITH CHINA

by
Ryan Haerer

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Abstract

How important are fisheries to the most important strategic risks for the United States? Can a broader thinking about what should constitute food security allow the US to invest strategically in aquaculture while enhancing its position in geostrategic competition with China? I find in this study that the US does have opportunities to help some other strategically important countries address shortfalls they might experience if wild-capture fisheries were to collapse. That can help their food security and the US' national security simultaneously by helping keep countries stable. But I also find that the US is significantly lagging behind China's global aquaculture leadership, and that US actions to catch up would need drastic levels of infrastructure funding. I identify that the Chinese aquaculture industry is so far advanced relative to other countries that they would control nearly half of the world market for fish by 2035 should capture fisheries collapse. I also find that numerous countries of strategic importance to either the US, China, or to both, are very reliant on fisheries compared with the global average. The research identifies that an absence of strategic action by the US will ensure that China's aquaculture advantage will allow it to be the key global provider of a critical resource demanded by many countries of interest to the two countries, granting Beijing extreme leverage in food security over those countries and an improvement in the security competition with the US.

Research Study Reviewers:

Dr. Sarah O'Byrne

Dr. Katrina Kosec

Preface

Thank you to all of those who have assisted me over the years. You are too many to name, but I appreciate you. I'll do my best to always carry the torch and look for opportunities to help others on their respective journeys, as you did for me.

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Introduction

This research asks about America's food security efforts, and whether or not America's current approach to food security policy is in line with its most important security interests. If not, could a new framework for strategically understanding and acting on fisheries as a security threat and opportunity better help the US address its biggest security challenges, particularly in competition with China?

The definition of food security is problematic for US strategic interests, because it is a vague term, but generally narrowly used. As a result, resource competition and challenges - and especially those with food - are often not considered as highly as other "hard" security risks.

The US government currently has a Global Food Security Strategy (GFSS) based on a law passed by Congress. But it is a narrow focus on development work, while other government reports surveying key parts of the government have identified the biggest long-term risks to US security. The US government identified twenty-six external security risks, many of which food does or could play a role.[1] But the current expenditures under the GFSS only directly do work in two of those areas, by supporting foreign government stability and countering terrorism. New approaches to government food policies cannot solve all security problems, but they might prevent current challenges from becoming harder to overcome.

I attempted with this research to answer two fundamental questions: First, how well does the current US approach to food security programs through its Feed the Future

[1] U.S. Government Accountability Office. "Long-Range Emerging Threats Facing the United States As Identified by Federal Agencies" GAO-19-204SP: Published: Dec 13, 2018. https://www.gao.gov/assets/700/695981.pdf. See Appendix C.

and foreign aid align with the biggest US security challenges - namely, in the most important countries where improvements in or protection of food access could play a role in improving US security outcomes?

Second, the paper looks more deeply at fish - a unique area of food security because of the international interest in (and need for) utilizing declining fish stocks in international waters, and also the potential substitutability of those wild fisheries with fish farming operations - should sufficient investment be available. This is a unique area that should be of particular interest to China, the US, and the billions of others worldwide who rely on the ocean for food. This research asks: Can the US use strategic investments in aquaculture to address the security impacts of a potential future collapse of global wild-capture fisheries?[2] Specifically, this paper evaluates four frameworks for the US to manage risks and opportunities with fisheries and aquaculture - especially with regard to the US-China competition.

This research focuses on the potential for using advanced aquaculture systems on land. These recirculating aquaculture systems (RAS) require the construction of buildings, large tanks, and water filtration recycling systems, and thus require more capital to construct than simple cage farms located in ponds, rivers, or the ocean. But they can grow fish with less disease susceptibility than in nets cages in open waters; cyclical

[2] Edwards, Peter and Demaine, Harvey. "Rural Aquaculture: Overview and Framework for Country Reviews." For Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations. 1998. Accessed May 8, 2021. http://www.fao.org/3/x6941e/x6941e00.htm#contents.
The authors write: "FAO in 1988 introduced a definition of aquaculture which reduces its confusion with capture fisheries: *Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resources, with or without appropriate licences, are the harvest of fisheries*."

disease outbreaks are a major risk for traditional approaches to global aquaculture growth.[3] RAS generally have little to no impact on the surrounding environment.

I find in this study that the US does have opportunities to selectively help some strategically important countries address shortfalls they might experience if capture fisheries were to collapse. That can help their food security and the US' national security simultaneously by helping keep countries stable. But I also find that the US is significantly lagging behind China's global aquaculture leadership, and that US actions to catch up would need drastic levels of infrastructure funding to be of consequence.

II. Background - Definitions and Applications of the Concept of Food Security

I need to first discuss what food security is before considering the ways in which the US may want to consider it differently. This section begins with a general review of the concepts of food security, discussing how users define the term differently and the functional areas of food policy. Then it moves into a discussion of food security in US policy, and what this paper intends to test as a new framework.

Policymakers and scholars approach food security from a few different angles. Food security as a term means different things to people and countries depending on the context and viewpoint of the user. Food is essential to all people, so some definitions think of food security simply as having adequate access to a certain quantity of food. Some definitions build on this but go further to describe having high quality and nutritious food. These definitions focusing on the individual may be used in domestic

[3] Schoonover, R. C. Cavallo, C. I. Caltabiano, I. "The Security Threat That Binds Us: The Unraveling of Ecological and Natural Security and What the United States Can Do About It." Edited by F. Femia and A. Rezzonico. The Converging Risks Lab, an institute of The Council on Strategic Risks. Washington, DC. February 2021. Page 65.

policy discussion in the US or more commonly in the west when thinking of international development efforts.

Others look at food security as a systems approach, ensuring the system that enables people and countries to have such adequate access to food for individuals is protected. This may mean ensuring that food is protected while growing from various risks to agriculture, from weather to terrorism; during processing to ensure it is handled safely, or to ensure supply chains function properly despite shocks.[4]

The last set of definitions looks at food security as a part of national security. This may be as a trade tool in cooperation with other states, or in competing with other states over access to limited resources, or in some other usage. So although the definitions of food security vary, what is most important is to ensure that however an individual or state defines it, that one is fully assessing the situation in which you need the food security to exist.

A. Roles of Food in Security

These definitional differences lead to several different schools of thought about security and food. Food, and the security aspects related to food, have existed for millennia. Food is a tool to enable improving situations; but it can be a part of conflict in various ways. It is critical and can drive behavior, so we think of food as a resource to be managed or protected. Sometimes that means securing the food system to deliver food where it is needed, and sometimes it is about protecting ecosystems. All of these different angles thinking of food leads to a last grouping missing in the US policy sphere: that

[4] Wilson Center. "Food Systems and National Security: The Science in Strategy". Event. May 23, 2019. Accessed January 25, 2021. https://www.wilsoncenter.org/event/food-systems-and-national-security-the-science-strategy

strategic planning around food - or the lack of a strategy - can have important consequences for national security.

1. **Access to food secures life - for the individual and the state**

One school of thought looks at food security as protecting life. For the individual, securing food is the first priority. Only once one has access to food can they consider other activities in life. The UN's report on global food security and nutrition states that "in 2019, close to 750 million – or nearly one in ten people in the world – were exposed to severe levels of food insecurity".[5]

Countries may also look at ensuring adequate food as a critical means to protect its own stability. A state can maintain power by maintaining access to food, especially when it is in short supply. Some actors may gain power by providing food to those who cannot access it; those actors can be a threat to state legitimacy.

Most countries looking at this level of security, of simply providing enough, are usually measuring their level of food by calories. Fulbrook, writing on the people of Laos, says that "Their health and vitality and consequently that of society are inseparable from robust food security. Poor or widespread food insecurity, as is the case with Laos, makes for people who are weak and if they are weak then so is their society upon which rests national security that the state bears responsibility to ensure. The state then is failing in its duty to provide basic national security."[6]

[5] Food and Agriculture Organization of the United Nations et al. "The State of Food Security and Nutrition in the World 2020: Transforming Food Systems for Affordable Healthy Diets." 2020. Accessed May 8, 2021. http://www.fao.org/3/ca9692en/ca9692en.pdf. Page xvi.
[6] Fulbrook, David. "Food as Security." Food Security, no. 2 (March, 2010): 5-20.

For some states, simply providing enough food is as far as food and its national security efforts are intertwined. But some states are endowed with different geography and natural resources, and some can produce significantly more food than others. They may look at food and security from a different lens, because food can be an opportunity for them to improve their position in the world.

2. Food security as an enabler

A second thought process is food as an enabler. This comes in multiple forms. First, improving the efficiency of agricultural production in a less developed country enables individuals to grow more food with less work.[7] International development organizations like the World Bank focus on the special role of agricultural growth in development because it is "two to four times more effective at reducing poverty than growth originating from other sectors."[8]. More agricultural efficiency leads to more market opportunities, frees labor, and increases income, often first for the rural, nonfarm economies in the developing world that provide 35-50 percent of all rural income.[9] That process ideally continues to becomes a cycle of economic advancement for the nation as a whole as the country undergoes a structural transformation from an economy based on agricultural employment to a more advanced industrial or service economy where most people do not participate in agriculture.[10]

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[7] Townsend, Robert, et al. "Ending Poverty and Hunger by 2030: An Agenda for the Global Food System." World Bank Group. 2015. http://documents1.worldbank.org/curated/en/700061468334490682/pdf/95768-REVISED-WP-PUBLIC-Box391467B-Ending-Poverty-and-Hunger-by-2030-FINAL.pdf
Page 9.
[8] Ibid, 7.
[9] Haggblade, Steven, Hazell, Peter, B.R., and Reardon, Thomas. "Strategies for Stimulating Equitable Growth in the Rural Nonfarm Economy." In "Transforming the Rural Nonfarm Economy", ed. Haggblade, Hazell, and Reardon. International Food Policy Research Institute. The Johns Hopkins University Press. 2007. Page 396.
[10] Paarlberg, Robert. "Food Politics: What Everyone Needs to Know." Oxford University Press. 2010. Page 2.

Food security can also be an enabler for some developed countries with already advanced agricultural systems. Those with excess production or production expertise in a good may trade to gain something advantageous for the country. But this strength can become a vulnerability too, if countries or sectors of a country depend on a certain level of income from food trade, and it is disrupted – agricultural producing groups generally carry outsized political weight.[11] China was able to apply tactical pressure the last several years in trade negotiations with the United States by hurting America's farm exports, a constituency critical to the US president's support. Generally, global food and agricultural policy is heavily driven by protectionist measures that distort prices and markets by countries fearing the loss of access to critical food supplies or interested in supporting agricultural constituencies.[12]

3. Food and nutrition as a tool

Excess production capacity can also be used to deliver humanitarian aid, as we will see later. Food security is sometimes considered as simply about providing enough calories. But the World Bank highlights the importance of nutrition to reduce stunting and wasting in children and improve productivity generally.[13] Improving nutrition for mothers and children is especially powerful for development outcomes.[14] US development approaches are very much interested in these endeavors, because delivering nutrition can be a tool for policy makers in some situations where it is desired but not currently present.

[11] Ibid, 6.
[12] Ibid, 4.
[13] Townsend, Robert, et al. Pages 9-10.
[14] Ibid, 10.

But this can also apply in the US, domestically. In US policy discussions rural areas generally support policies that increase benefits for farmers. Non-agricultural areas generally think of food policies as critical to improving the health and nutrition of food and decreasing prices for consumers.[15] The most efficient crops that are the cheapest to mechanize and produce in abundance are not always the most nutritious, or the most profitable, or even grown for humans to eat. The food that would be most nutritious to help populations to improve health is not what many agricultural communities specialize in.

Nutrition is not only an urban weakness. Plenty of rural areas are poor and suffer from poor nutrition and are not major agricultural producing areas, like deserts and mountainous regions. Delivering nutrition here or to any areas where food and nutrition is poor can be a tool for domestic influence.

4. <u>Food as part of conflict</u>

The Council on Strategic Risks' 2021 report explains that "(s)ecuring food resources has long been an important issue for national security. Food insecurity can be a factor in conflict, instability, social unrest, and migration."[16] Food insecurity due to food prices can cause destabilization of governments like in the Arab Spring, and conflicts can occur over access to food resources like fisheries within or between states. Food insecurity can also result from conflict, due to disrupted production or supply chains as a result of the conflict, or intentionally, as a weapon of war.

[15] Paarlberg, Robert. "Food Politics: What Everyone Needs to Know." Oxford University Press. 2010. Page 6.
[16] Schoonover, R. C. Cavallo, C. I. Caltabiano, I. Page 9.

But food need not be a part of active conflict to be a resource in national security competitions. China and other countries are making forward looking investments into acquiring overseas arable farmland, since farmland globally is limited but populations continue to grow. Gassert and Scott assert that while China and the US are engaged in a struggle over resources - including agricultural production - China has a better coordinated strategy and implementation plan. The US has better natural capability to produce food - a resource both major powers need - but less strategic vision to make the production match national security interests.[17]

5. Threats to food: a resource risk to be managed

Gassert's and Scott's assessment was extensive, but it did not evaluate fisheries. Fish are a complicated resource to examine. They move freely, are often found in international waters, and face pressures on their resilience from both clearly identifiable nation state actors and hard to pinpoint threats, like pollution and ocean acidification.

Protecting the benefits from fisheries is an example of looking at food security as a resource risk that must be managed. This is generally a concern of nation states and international and non-profit organizations. The previous sections discussed the importance of food to individuals and the state, and looked at how states may use food to their advantage. This section looks at protecting food resources, and the threats that occur if they are not managed well.

[17] Gassert, Francis and Scott, Wyatt. "Great Power Resource Competition in a Changing Climate". *New Security Beat*. Wilson Center. January 13, 2020. Accessed online January 27, 2021. https://www.newsecuritybeat.org/2020/01/great-power-resource-competition-changing-climate-americas-natural-security-index/

The US intelligence community provides annually an assessment of threats to the US. The 2019 Worldwide Threat Assessment discusses food and water security being at risk from ecological and environmental degradation, including climate change. The assessment states that extreme weather changes "combined with poor governance practices—are increasing water and food insecurity around the world, increasing the risk of social unrest, migration, and interstate tension in countries such as Egypt, Ethiopia, Iraq, and Jordan."[18] This destabilization is a security risk for the US. It also discusses the risks of illegal, unreported, unregulated fishing helping fund transnational organized crime and causing ecological damage and economic effects.[19] Most commercial scale fisheries are a mobile stock that migrate into and through international waters, so they are much more complicated to protect than land based agricultural production under a state's control.

External organizations have calculated additional threat assessments for the US that focus on climate change and on ecological risks. The Council on Strategic Risks assesses that "(l)osses of insect and other pollinators pose a perilous risk to some parts of food production. Meanwhile, industrialized countries depend critically on the global food network, which is becoming increasingly vulnerable to concurrent acute shocks."[20]

Discussions of protecting food as a resource is interesting in that it sometimes overlaps with the previous sections of food as an enabler, and how one sees the situation depends on one's role in the activity. National security planning with regard to the

[18] U.S. Intelligence Community. "Worldwide Threat Assessment of the United States Intelligence Community". 2019. https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR---SSCI.pdf
[19] Worldwide Threat Assessment.
[20] Schoonover, R. C. Cavallo, C. I. Caltabiano, I.

opportunity and risks with food must always consider the viewpoint of strategic competitors. China and its distant water fishing fleet is an example of this. It helps feed their population, helping the state achieve their own food security and enhance their economy. China is certainly not the only actor participating in destructive fishing practices, but they are a significant player. Beijing's quest to enhance Chinese security through extensive fishing may be leading to insecurity for other countries that depend on that migrating resource that can have destabilizing effects. Spijkers, et al. examined decades of conflicts over fisheries and found that they are increasing and that since 2000, "conflict primarily involved Asian countries clashing over multiple and nonspecified species linked to illegal fishing practices."[21]

III. US Policies Related to Food Security

We have seen that food security is defined in many ways, and that there are several approaches to think of food as it relates to national security as an enabler and a risk. This leads us to the discussion of US policies related to food and national security. The US food security history of the last decade plus can roundly be lumped into three independent buckets. There is no overarching strategy for security outcomes related to food, although the US does have a global food security strategy.[22] The three silos of food related work are: International development efforts in less developed countries; domestic agricultural advancement through various policy tools; and protection of international

[21] Spijkers, J., Singh, G., Blasiak, R., Morrison, T.H., Le Billon, Österblom, H. "Global Patterns of Fisheries Conflict: Forty Years of Data." Global Environmental Change. Volume 57. July, 2019. https://www.stockholmresilience.org/publications/publications/2019-05-30-global-patterns-of-fisheries-conflict-forty-years-of-data.html.

[22] U.S. Government Global Food Security Strategy FY 2017-2021.

fisheries. This section will review those areas, before discussing areas of concern with US food security interests.

A. International Development and the US Global Food Security Strategy

Despite threat assessments recognizing the threat, the most recent US National Security Strategy (2017) discusses food on only two occasions. It mentions in passing the importance of protecting critical infrastructure, noting its importance to the domestic food supply chains. The more significant discussion about food states, "the United States will continue to lead the world in humanitarian assistance", continuing "We will support food security and health programs that save lives and address the root cause of hunger and disease. We will support displaced people close to their homes to help meet their needs until they can safely and voluntarily return home."[23]

The US Global Food Security Strategy (GFSS) was released after Congress passed the US Global Food Security Act in 2016.[24] The strategy does not encompass all of the functional or geographic areas in which food relates to national security at home or abroad. The current strategy is focused on international development and enabling poverty reduction and government enhancement in the developing world. It is a vestige from the mindset developed in the Cold War and in the post-Cold War period where the US was the unrivaled global leader. The US did not have major challengers to itself or the global system, and most of its military efforts were focused on its efforts in the Middle East. It had the ability to focus on improving its standing and working on soft

[23] U.S. Government. "National Security Strategy of the United States". 2017. https://trumpwhitehouse.archives.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf
[24] U.S. Government Global Food Security Act.Text - S.1252 - 114th Congress (2015-2016): Global Food Security Act of 2016." Legislation, July 20, 2016. 2015/2016. https://www.congress.gov/bill/114th-congress/senate-bill/1252/text.

power approaches to improving its influence and standing up for US values without diverting resources from other hard security matters. The GFSS reflects this relatively stable security situation. Currently most of the program is executed through the Feed the Future program. It is primarily implemented through the US Agency for International Development (USAID), and focuses largely on the special benefits of agricultural development, although many agencies play a role. Ensuring food security and working toward the UN development goals is about making American values visible to the world, which has some security benefits, but it is not a strategic approach to all risks identified in the threat assessments. The bulk of its work focuses on twelve target countries, although it does work in other aligned countries and in some strategic regions.[25] The US also delivers humanitarian assistance on an as needed basis. This can be used generally to support efforts against famines or after natural disasters.

Funding mechanisms for US food security and agricultural development activities are complex. The Congressional Research Service estimates that the US government spent approximately "$1.7 billion in FY2010 to $2.6 billion in FY2013 before declining to $2.4 billion in FY2014".[26] They also describe that the government also spends significantly on "nutrition-specific activities under other global health programs and multilateral institutional investments in both health and food security."[27] Since then, GAO estimates the US Government has spent $25 billion in disbursements for global food security assistance (in the years 2014-2018), although the scope is broad and

[25] U.S. Government Global Food Security Strategy FY 2017-2021.
[26] Lawson, Marian, Schnepf, Randy, and Cook, Nicolas. "The Obama Administration's Feed the Future Initiative." Congressional Research Service. Report 7-5700/R44216. July 25, 2016. Accessed online February 26, 2021. http://nationalaglawcenter.org/wp-content/uploads//assets/crs/R44216.pdf
[27] Lawson, et al references: CRS Report R43115, U.S. GlobalHealth Assistance: FY2001-FY2016, by Tiaji Salaam-Blyther.

funding totals difficult to calculate.[28] One can roughly suggest the US spends between $4 and 5 billion annually on international food security assistance programs.[29]

B. Ecosystem and Food Protection: Fisheries

Congress passed the Illegal, Unreported, and Unregulated Fishing Act in 2015. It directs government agencies to undertake a variety of activities to limit the effects of IUU fishing.[30] IUU fishing is now reported regularly in the Improving International Fisheries Management Reports to Congress from NOAA, because as the 2019 report explains, "the FAO considers IUU fishing a serious threat to high-value fisheries that are already overfished; to marine habitats, including vulnerable marine ecosystems (VMEs); and to food security and the economies of developing countries. IUU fishing activities have widespread economic and social consequences, including depriving legitimate fishermen of harvesting opportunities."[31] The NOAA report suggests that the illegal fishing could be worth tens of billions of dollars annually. Various US agencies are involved in these efforts to protect wild fisheries. Meanwhile, US aquaculture production is growing but is limited, and the US remains a major seafood importer.

IV. Why the US' Current Food Security Framework Is Not Optimized

There is not one unified food security plan that integrates within the US security sphere. The international development approach, fisheries management operations, and

[28] GAO. "Letter to Congress number GAO-21-47R". November 19, 2020. Accessed online February 26, 2021. https://www.gao.gov/assets/720/710772.pdf
[29] This paper will use the round figure of $4.5 billion annually.
[30] U.S. Government. "Text - H.R.774 - 114th Congress (2015-2016): Illegal, Unreported, and Unregulated Fishing Enforcement Act of 2015." Webpage, November 5, 2015. 2015/2016. https://www.congress.gov/bill/114th-congress/house-bill/774/text.
[31] National Oceanic and Atmospheric Administration. "Improving International Fisheries Management - 2019 Report to Congress".

even domestic agriculture plan all deal in some form with food and national security. However, it does not appear that they have a key focus on the key national security risks we have seen earlier in the risk assessments from external groups and the US intelligence community. Gassert and Scott reminded us that although the US has the advantage in food production, the Chinese own the advantage in strategic planning and government coordination of efforts toward those plans.

Our international development approaches have a limited focus formed in a previous era. They are important and have potential, but due to the nature of the type of long-term projects are difficult to implement in all places. So they are limited to certain countries meeting certain criteria that would lead to development project success, but that may not be the most strategically important locations.

The US Department of Agriculture (USDA) is primarily interested in developing the US agricultural industry, although it does have a foreign agricultural service. However, USDA and its foreign agricultural service historically have looked at international development work primarily as a chance to develop markets to sell goods instead of a means to deliver security results for the US.

This disjointed alignment in development and agriculture is just one example of US government efforts that do not align with our most important national security goals. Some elements of the Department of Defense have not yet caught up and adjusted with the resurgence of great power competition after spending the last two decades ready to fight non-state terrorist actors. Although the DoD is one of the leading agencies looking at climate risk - due to its huge risk - there is not a uniform understanding throughout the services that climate is a significant problem. The military emphasis on hard power risks

is not easy to convince of the security risks of environmental damage or importance of protecting food security as a way to help win wars.

The US' disjointed approach to areas where food is involved with security does not seem the best framework for the multilayered risks identified repeatedly in the threat assessments. The National Security Strategy directs activities spanning risks from great power competition with China and Russia to environmental risks, but makes mention of food only in passing. Certainly, food is not able to solve all of the areas the security strategy must address. But this paper attempts to understand if the current framework could be improved by more closely aligning food related government spending to security concerns with food, as there is likely more overlap than currently exists, and more strategic opportunities to be had with centralized planning and investment on risks and opportunities with fisheries.

Kimberly Flowers of CSIS argued that the US Food Security Strategy was not strategically sufficient. Her main criticisms were that it was too detailed, but lacked a strategic focus, and laid out five outcomes to improve the strategy.[32] I support the conclusion that the strategy needs rework, and that food security should be elevated in national security discussions, but differ on several of her points. That is likely because we take a different view of food security. Flowers appears to approach food security primarily from the development realm. She gives acknowledgment and uses as arguments at several points that food security supports US economic and security interests. But one key weakness not bridged is her regular reference to the positive impacts of global food

[32] Flowers, Kimberly. "US Policy Roadmap: A Drive to Transform Global Food and Nutrition Security." Center for Strategic and International Studies. January 2019. https://www.csis.org/analysis/us-policy-roadmap-drive-transform-global-food-and-nutrition-security

security, while referring back to the fact that the approach to improving food security only works in countries with a preordained set of criteria: applicable countries should be willing partners with stable governance. That seems to undermine the argument for using food security development: that it can prevent risks from unstable situations that cause a security risk.

The Council on Strategic Risks report recently released makes suggestions that ecological security risks should be elevated to the White House and integrated with strategic planning. The paper emphasizes ensuring resilience to these risks, and many of the suggested policy recommendations that are more prescriptive talk about efforts to ensure collaboration where possible to address issues of shared governance, like international fisheries.[33]

V. The Missing Opportunity Costs of Food Policies in Security Calculations:

Might a new framework allow us better security balance against China through different thinking about what constitutes food security plans?

What we have not yet seen is significant discussion of the US strategically incorporating fisheries security risks long term, especially with regard to competition with China, and applying calculations to see if we might shift investments toward new approaches with more government direction and assistance in case our current approaches to protecting fisheries do not succeed. Most discourse focuses on means to better manage and protect fisheries, with less emphasis on how to prepare in case those efforts were to fail.

[33] Schoonover, R. C. Cavallo, C. I. Caltabiano, I.

For example, the US is committed to various activities to protect international fisheries. However, global fishery resources are being utilized at an unsustainable clip. Despite all governance efforts, it is possible that more and more of these fisheries collapse due to fishing and environmental pressures.[34] If the US has not been putting equivalent amounts into developing our own aquaculture resources with a strategic eye toward what might happen in cases that fishery is not totally protected if ocean fisheries were to collapse, is that the right approach? If China were to continue on the path of fish farming while exploiting the fisheries now, would they actually be helping themselves by getting more fish out of the oceans while significant stocks remain and then leaving themselves in a better emboldened position by having more aquaculture farming than anyone else in the world when the fisheries collapse? Those aquaculture production capabilities would increase significantly in value when capture fisheries are depleted. Should this scenario occur, the US would have found itself investing for years in fisheries protection efforts that failed but not building out aquaculture, while China had been exacerbating our expenditures and enhancing their economy. This would be a zero-sum effort with the US on the losing side of both. If that situation would come to pass, the US would then be in an even worse situation in competition with China going forward, finding itself further mismatched with regard to being a provider of a coveted food resource of high value and need for billions of people in countries of strategic importance.

Might the US be able to dilute the risks it faces in case of collapsed fisheries through policy changes that direct additional strategic investments in supplying fish

[34] Food and Agriculture Organization of the United Nations. "The State of World Fisheries and Aquaculture - 2020." 2020. Accessed February 3, 2021. https://doi.org/10.4060/ca9229en.

through means other than capture fisheries? The technology for aquaculture is not complicated, and many species of fish can be commercially cultivated in farms on land. Some can realistically only be farmed or ranched in the ocean, but the US has essentially no offshore farming at this moment. Environmental concerns and commercial fisheries groups are important factors in why the US has not established a more robust offshore or onshore aquaculture industry. Any policy framework must take those concerns into account and propose solutions for addressing them as part of the strategy.

This paper will identify key countries of concern for the US, and examine whether a new strategic framework can help the US improve its position in competition with China in the world of fisheries - a particularly interesting and important part of national security, which is not generally considered in US food security strategic planning.

Anticipated Outcomes

I expect that our outcomes will find that current US food security expenditures are not aligned with our biggest security risks. That would not be surprising, because the current use of the food security term is related to the United Nations' definition, because pursuing the development agenda is important on its own right for the US' interest, and because budgets are not unlimited.

However, I also think that I will find by evaluating new frameworks within the special food and security sector with fisheries that there will be countries which might be more important for broader or higher priority US security interests than the development agenda because of their particular susceptibility to global fisheries risks.

Finally, I anticipate that broadening our approach to food security focused primarily on agricultural development to include managing risks and opportunities with

capture fisheries by investing in aquaculture might help the US has the capacity to ensure a means of continuous fish supply to key countries of importance in case of a collapse of capture fisheries, enhancing US influence and our strategic positioning with China.

VI. Methodology – Evaluations 1, 2, 3

A strong US is good for global food security, and global food security efforts have been good for the US. But we face a new security environment in which the current food security approach in the US appears it has not been optimized to best enhance the ability of the US to maintain its competitive edge as the global leader - and thus its ability to promote food security efforts globally long term.

The previous section explained my theory that the US needs a strategic approach to food to help defeat those challenges. If we can't achieve our strategic goals, we at some point won't be able to achieve our development goals. That may be due to a loss of privileged status as a world leader, or simply because other new challenges arise that make development spending less politically feasible at home. This research takes on a four-part evaluation:

1. Creating a method to identify the most important countries of strategic significance to the US and China;
2. Evaluating the alignment of the US' current food security operations with regard to the identified strategically-important countries;
3. Narrowing the scope to evaluate the importance of fisheries, and the risks and opportunities they provide for the US with regard to food security in strategically important countries; and

4. Evaluating new frameworks to consider for a more strategic approach to addressing fisheries opportunities and risks through aquaculture investments. More information on each evaluation follows:

Evaluation 1 - What countries are most strategically important to the US and China?

I first attempted to identify which countries are most important to the US and China to see where food security activities might potentially impact the competition between the two countries. I created a rubric to assess the importance of 178 countries identified in the Global Fragility Index for each country.[35] The scoring rubrics are found in Appendices A and B, respectively.

I first identified the biggest US national security challenges using information from a survey undertaken by the GAO that surveyed the US government about what each department sees as the most important long-range security risks to the US. This 2018 unclassified report identified 26 threats, identified as follows: "long-range emerging threats—those that may occur in approximately 5 or more years, or those that may occur during an unknown timeframe—as identified by various respondents at the Department of Defense (DOD), Department of State (State), Department of Homeland Security (DHS), and the Office of the Director of National Intelligence (ODNI)."[36] Appendix C lists those identified threats.

[35] The Fund for Peace. "Fragile States Index." 2018. https://fragilestatesindex.org/
[36] U.S. Government Accountability Office. "Long-Range Emerging Threats Facing the United States As Identified by Federal Agencies" GAO-19-204SP: Published: Dec 13, 2018. https://www.gao.gov/assets/700/695981.pdf

I had to translate some of the national security risks identified in Part A from concepts into specific countries where those risks are the highest. I translated terrorism risks into countries using data from the Cost of War project.[37]

The Cost of War data also included all countries where the US has had active combat in recent years. And since China, Russia, Iran, and North Korea were already covered by other risks listed by the GAO, I found that the terrorism list was an appropriate complement and sufficient in concluding all the main hard security risk countries.

For the remaining risks named without countries, I chose to limit these translations to those security risks that could clearly be affected by government policies related to food security activities. Translating all risk concepts was beyond the scope of this study, and for many would not be particularly useful. I focused on migration and climate change as the two risk concepts most necessary to be translated from non-country risks into measurements that allow countries to be an outcome. I used a multiplication combination of national fragility ranking from the Global Fragility Index and UN population to estimate a ranking factor in the security importance calculation to cover both risks.[38]

I then added a variety of other information to the rubric calculating the strategic importance of countries to the US. I first included all nuclear weapons states as strategically important countries. I then used information from New America's Natural

[37] Savell, Stephanie. "United States Counterterrorism Operations 2018-2020". Costs of War Project. Watson Institute for International and Public Affairs. February 2021. https://watson.brown.edu/costsofwar/files/cow/imce/papers/2021/US%20Counterterrorism%20Operations%202018-2020%2C%20Costs%20of%20War.pdf

[38] The Fund for Peace.

Security Index, which had calculated data on the most important countries for both the US and China on a variety of different data sets.[39]

I then repeated the process to find the most strategically important countries for China. However, some of the criteria were different than the criteria identified for the US. For China, I removed the terrorism listings and other categories appropriate for the US, and added for China's calculation its territorial conflicts. Although not all territorial concerns are active fighting, I included them because China asserts its security interest is based in acting from a defensive position. Boundary disputes are areas of interest to protecting Chinese interests in its regional area in which it wants to influence. The chart below includes the twenty-five countries in which the US and China share mutual interest.

Table 1: Countries of Strategic Importance to Both the US and China

Countries of Strategic Importance to Both the US and China (25)				
Australia	India	Malaysia	Russia	Switzerland
Bangladesh	Indonesia	Myanmar	Saudi Arabia	Taiwan
Brazil	Iran	North Korea	Singapore	Thailand
France	Israel and West Bank	Pakistan	South Africa	United Kingdom
Germany	Japan	Philippines	South Korea	Vietnam

<u>Evaluation 2:</u> How well does the US Feed the Future Program and US and Chinese foreign aid assistance line up with the US' and China's strategically most important countries as identified in Evaluation 1?

This evaluation was straightforward. I simply compared the US Feed the Future focus countries and cross-referenced them with those countries identified in Evaluation 1

[39] Gassert, Francis and Scott, Wyatt. "Great Power Resource Competition in a Changing Climate". *New Security Beat*. Wilson Center. January 13, 2020. Accessed online January 27, 2021.

to see how many of them overlapped. I then did similar for high-ranking foreign aid relationships for both the US and China using New America's calculations. The specific questions follow. Results are covered in the discussion section.

Question 1: Compare Feed the Future focus countries to strategically important countries.

Question 2: Compare strategically important countries and Feed the Future focus countries with the top 10 most aid dependent countries from the US and China.

The information on aid dependency is taken from New America's Natural Security Index.[40] It is important to note that this government-to-government aid encompasses more than money for, or provisions of, food; but that it might include these resources to increase food security in the recipient countries. So although this measure goes beyond food security, the relationship may signal an importance factor of these recipient countries to the US or China that I did not capture in my importance methodology. I did not include this factor within the strategic country calculation because it was heavily weighted toward smaller states - per the New America statement - and I did not have a way to adequately account for the difference between a small island state's importance relative to a nuclear power, for example.

[40] Scott, Wyatt et al. "Great Power Resource Competition in a Changing Climate: New America's Natural Security Index." New America. October 23, 2019. Accessed November 27, 2020. http://newamerica.org/resource-security/reports/great-power-resource-competition-changing-climate/.

<u>Evaluation 3:</u> How Important Are Fisheries to Each of The Countries of Strategic Importance to the US and to China?

This evaluation attempts to quantify the relative importance of capture fisheries to each country of strategic significance to the US and to China. This measure is useful because it might signal the interest in future opportunities to leverage the country's weaknesses should capture fisheries be depleted.

I obtained data on capture fishery volumes for all types of finfish for each country from the UN Food and Agriculture Organization for the years 2014 through 2018.[41] I cleaned the total product capture data to focus on finfish only, eliminating other aquatic species of plants and animals. Aquaculture production capacities on land which might operate as a substitute if capture fisheries are depleted are generally best suited to finfish. I then created five-year averages from 2014-2018 for each country's total finfish capture. I chose not to evaluate trends in capture volume because I did not feel I could account for variability in stocks in this research.

I then created a value of the finfish capture fishery volume per capita for each country. This was an attempt to measure the importance of finfish fisheries to each country. This, intentionally, does not separate domestic consumption versus product captured for export. Evaluating aquatic species import and export data was beyond the scope of this work as I would not have been easily able to parse out the finfish portion of total export and domestic consumption quantities from available data. Evaluating the

[41] The FAO includes in the term "fish": fish, crustaceans, molluscs, and other aquatic animals, but excludes aquatic mammals, reptiles, seaweeds, and other aquatic plants. This research focuses on "Finfish": the type of fish most commonly associated with the word fish: those with fins and vertebrae, like tuna, salmon, or minnows.

relative importance of the capture fisheries between countries that utilize different amounts for export or domestic use is also an evaluation beyond the scope of this work.

Using the data as a ratio measuring finfish capture to total population provides a simple metric to compare across countries the generalized relative importance of these fisheries to each country. In the case studies that follow, this criteria allowed me to perform analyses to see how each might be relatively affected if these fisheries were to collapse, and how additional capital infusion for aquaculture farms might be able to influence each country differently. It is important to note that while the capture fishery data was most recent through 2018, I used 2020 population numbers because they were most recent. This measure is relative between countries, so I anticipate no negative impact on the results due to the different years within the ratio.

VII. Results for Evaluations 1, 2, and 3

Evaluation 1 - What countries are most strategically important to the US and China?

I used the criteria in Appendix A (for US) and Appendix B (for China) to find the countries with most strategic significance for each. I found 54 countries of importance to the US, and 34 countries of importance to China. Of those countries, 25 are important to both. Those countries are found in the following chart.

Table 2: The 63 Strategically Important Countries for the US and China

US ONLY (29)			BOTH (25)			CHINA ONLY (9)
Afghanistan	Iraq	Niger	Australia	Malaysia	Switzerland	Angola
Bulgaria	Ireland	Nigeria	Bangladesh	Myanmar	Taiwan	Bhutan
Cameroon	Kenya	Oman	Brazil	North Korea	Thailand	Brunei Darussalam
Canada	Lebanon	Peru	France	Pakistan	United Kingdom	Cambodia
China	Libya	Somalia	Germany	Philippines	Vietnam	Laos
Colombia	Luxembourg	Syria	India	Russia		Mongolia
Congo Democratic Republic	Mali	Tunisia	Indonesia	Saudi Arabia		Nepal
Denmark	Mexico	Turkey	Iran	Singapore		Turkmenistan
Egypt	Netherlands	Yemen	Israel and West Bank	South Africa		***United States***
Ethiopia	New Zealand		Japan	South Korea		

The regional breakdown for all these countries is found in the following chart.[42]

[42] This uses the UN Sustainable Development Goal regions.

Table 3: Regional Locations of Strategically Important Countries for the US and China

Region	Total	Countries
South-Eastern Asia	10	Brunei Darussalam, Cambodia, Indonesia, Lao People's Dem. Rep., Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam
Western Asia	8	Iraq, Israel and Palestine*, Lebanon, Oman, Saudi Arabia, Syrian Arab Republic, Turkey, Yemen
Southern Asia	7	Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Rep. of), Nepal, Pakistan,
Eastern Asia	6	***China***, Japan, Korea, Dem. People's Rep, Korea, Republic of, Mongolia, Taiwan Province of China
Western Europe	5	France, Germany, Luxembourg, Netherlands, Switzerland
Eastern Africa	3	Ethiopia, Kenya, Somalia,
Middle Africa	3	Angola, Cameroon, Congo, Dem. Rep. of the
Northern Africa	3	Egypt, Libya, Tunisia,
Western Africa	3	Mali, Niger, Nigeria
South America	3	Brazil, Colombia, Peru
Northern Europe	3	Denmark, Ireland, United Kingdom
Northern America	2	Canada, ***United States of America***
Australia/New Zealand	2	Australia, New Zealand
Eastern Europe	2	Bulgaria, Russian Federation
Southern Africa	1	South Africa
Central America	1	Mexico
Central Asia	1	Turkmenistan
Total:	**63**	

Evaluation 2: How well does the US Feed the Future Program and US and Chinese foreign aid assistance line up with the US' and China's strategically important countries as identified in Evaluation 1?

The predictions that the US Feed the Future program not being in alignment with US' most strategically important countries partially held true. One angle shows that the Feed the Future 2017 country lists identify programs operating in only six of the fifty-

four countries I identified as strategically important countries for the US: Bangladesh, Ethiopia, Kenya, Mali, Niger, and Nigeria.

But a different analysis tells a different story. Potentially, the Feed the Future targeting is relatively effective. The remaining focus countries - Ghana, Guatemala, Honduras, Nepal, Senegal, Uganda - do not rank as strategically important for the US. But that means that the strategically important countries do constitute fifty percent of the Feed the Future focus countries.

Nepal is a Feed the Future country of overlap in US and Chinese interests. It does not rank as a country of strategic significance for the US, but it is strategically important to China due to past border tensions. However, Nepal also ranks in the top 10 of China's military relationship countries, so potentially the strategic importance is more a positive than a risk.[43] Bangladesh is the only Feed the Future country for the US that is also strategically important to both US and China. The country should be of special interest for US policymakers.

When the top 10 aid dependent states are included, the US focus shows many states that are not strategically significant to US or China. However, US aid to Afghanistan and Somalia counterbalance the list. They are important as countries where the US has been involved in counterterrorism efforts.

An interesting area of overlap occurs with Ethiopia and Niger. They are Feed the Future focus countries. However, they are also both in China's top 10 list for aid so are likely of importance to them both, even though the calculation for strategic importance

[43] Scott, Wyatt et al.

did not capture them for China. These countries may be an area of particularly special interest for the US to consider in its competition with China.

Table 4: Which Feed the Future Countries and Aid Receiving Countries are Strategically Important to the US and to China?

	Feed the Future Focus Countries	**Top 10 US Aid Dependent Countries**[44] (Rank in Parentheses)	**Top 9 China Aid Dependent Countries**[45] (Rank in Parentheses)
Strategically Most Important Countries to Only US	***Ethiopia***, Kenya, Mali, ***Niger***, Nigeria	Afghanistan (tie 1), Somalia (tie 1),	***Ethiopia*** (7), ***Niger*** (10)
Strategically Most Important to Both	**Bangladesh**		
Strategically Most Important Countries to Only China	**Nepal**		Laos (2), Cambodia (3),
Strategically Most Important to Neither	Ghana, Guatemala, Honduras, Senegal, Uganda	Federated States of Micronesia (tie 1), Liberia (tie 1), Haiti (tie 1), Malawi (6), Jordan (7), South Sudan (8), Lesotho (9), Mozambique (10)	Djibouti (1), Kyrgyzstan (4), Dominica (5), The Bahamas (6), Montenegro (8), Vanuatu (9),

<u>Results: Evaluation 3:</u> How Important Are Fisheries to Each of The Countries of Importance to the US and to China?

Calculating the data on the importance of finfish production was a measure of creating a five-year average and creating a per capita metric (2014-2018 average capture value to the 2020 population of each country). Results for the average per capita (per

[44] Scott, Wyatt et al.
[45] Scott, Wyatt et al.

1000 persons) importance of capture fisheries score for each grouping of strategic interest countries is as follows:

Table 5: Importance of Fisheries by Strategic Significance Grouping

Strategic Significance Category	Number of Countries	Average Annual Capture (tons)	Average Annual Capture Per Capita (2020 population, per 1000)
All Strategically Important Countries	63	959414.33	15.39
To Both	25	1806997.14	12.99
Only US	29	738847.97	18.80
Only China	9	583971.31	10.42
All US	54	1021988.163	16.22
All China	34	1147544.45	12.49

Importance of Fisheries to All Countries Strategically Important to the US and China

The average annual capture per capita (per 1000) for all countries was 15.39. It was beyond the scope of this research to calculate ratios for all countries worldwide. However, a measure of comparison is below. 18 of the top 25 marine capture production fisheries countries are in the strategic countries list.[46] It is important to caveat that the marine capture production fishery figure is not limited to finfish, and it is limited to marine areas only. So, while helpful, it is not a straight comparison to finfish capture in marine and inland waters.

[46] UN FAO data Norway, Chile, Morocco, Iceland, Mauritania, Spain, and Argentina are in the top 25 marine capture countries, but not significantly important to either the US or China.

Table 6: Importance of Annual Freshwater and Marine Finfish Capture to All 63 Countries Strategically Important to the US and China
(2014-2018 average tons (includes marine, freshwater, and diadromous fishes): 2020 population estimate)

Country	Annual Average Capture (tons, 2014 - 2018)	Average annual capture per capita (2020 population, per 1000)	Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita (2020 population, per 1000)
Peru	4203101.40	127.47	Yemen	148088.40	4.97
Denmark	733173.00	126.58	Australia	119998.40	4.71
New Zealand	393947.60	81.70	Mali	94314.60	4.66
Oman	319258.80	62.51	Libya	27090.20	3.94
Ireland	217056.20	43.96	Nigeria	749017.40	3.63
Malaysia	1270070.00	39.24	Turkey	297357.20	3.53
Myanmar	2010389.60	36.95	Egypt	323025.00	3.16
Cambodia	609067.60	36.43	India	4328300.60	3.14
Russian Federation	4466198.20	30.60	Brazil	657698.60	3.09
Taiwan Province of China	724707.20	30.43	Germany	241910.60	2.89
Viet Nam	2504336.40	25.73	Kenya	141799.60	2.64
Netherlands	378443.80	22.09	Congo, Dem. Rep. of the	234742.00	2.62
Japan	2727663.80	21.57	Turkmenistan	15000.00	2.49
Indonesia	5848617.20	21.38	Pakistan	471161.00	2.13
Korea, Republic of	1072120.00	20.91	Somalia	28900.00	1.82
Thailand	1319252.20	18.90	Saudi Arabia	54133.60	1.55
Brunei Darussalam	7949.20	18.19	Colombia	78892.00	1.55
Philippines	1886224.20	17.21	Niger	32965.80	1.36
Angola	473281.00	14.40	Iraq	37070.80	0.92
United States of America	**4061766.80**	**12.27**	Nepal	21514.00	0.74
Canada	431663.40	11.44	Bulgaria	4313.80	0.62
Bangladesh	1609166.60	9.77	Lebanon	3393.40	0.50
Mexico	1223530.20	9.49	Ethiopia	51761.00	0.45
South Africa	561219.40	9.46	Israel and Palestine	4369.00	0.32

Lao People's Dem. Rep.	67117.40	9.22	Syrian Arab Republic	4236.60	0.24
United Kingdom	574740.00	8.47	Switzerland	1861.40	0.22
Iran (Islamic Rep. of)	693005.60	8.25	Singapore	877.00	0.15
Tunisia	93003.40	7.87	Afghanistan	1860.00	0.05
Cameroon	208199.20	7.84	Bhutan	11.00	0.01
China	**10966386.40**	**7.62**	Mongolia	34.80	0.01
Korea, Dem. People's Rep	187086.00	7.26	Luxembourg	0.00	0.00
France	425663.00	6.52	**AVERAGES**	**959414.33**	**15.39**

Fisheries Importance to 25 Countries Strategically Important to Both:

Interesting here is that the top eleven countries (excluding the US) where fisheries are most important relative to population are in Asia. All except for Bangladesh fall above the average tons per capita (per 1000 persons) of 12.99, meaning that capture fisheries are relatively more important to them than to the countries with smaller ratios. China, with the largest absolute capture, actually sits in the middle of the pack. Its ratio places it behind the eleven Asian countries already mentioned, as well as the US, South Africa, the UK, and Iran.

Table 7: Importance of Annual Freshwater and Marine Finfish Capture to US, China, and the 25 Countries Strategically Important to Both of Them, 2014-2018 (2014-2018 average tons (includes marine, freshwater, and diadromous fishes): 2020 population estimate)

Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita (2020 population, per 1000)	Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita (2020 population, per 1000)
Malaysia	1270070.00	39.24	Iran (Islamic Rep. of)	693005.60	8.25
Myanmar	2010389.60	36.95	***China***	***10966386.40***	***7.62***
Russian Federation	4466198.20	30.60	Korea, Dem. People's Rep	187086.00	7.26
Taiwan Province of China	724707.20	30.43	France	425663.00	6.52
Viet Nam	2504336.40	25.73	Australia	119998.40	4.71
Japan	2727663.80	21.57	India	4328300.60	3.14
Indonesia	5848617.20	21.38	Brazil	657698.60	3.09
Korea, Republic of	1072120.00	20.91	Germany	241910.60	2.89
Thailand	1319252.20	18.90	Pakistan	471161.00	2.13
Philippines	1886224.20	17.21	Saudi Arabia	54133.60	1.55
United States of America	***4061766.80***	***12.27***	Israel and Palestine	4369.00	0.32
Bangladesh	1609166.60	9.77	Switzerland	1861.40	0.22
South Africa	561219.40	9.46	Singapore	877.00	0.15
United Kingdom	574740.00	8.47	**AVERAGES**	**1806997.14**	**12.99**

Fisheries Importance to 29 Countries Strategically Important to Only the US:

The average importance for capture fisheries for countries strategically important to the US only was nearly fifty percent higher than the category with countries of shared importance. This was heavily skewed by the importance of Peru and Denmark, whose per capita rankings were both approximately six times the overall category average. But

those were not the only countries with high rankings of importance; eleven of the twenty-nine had ratios over seven. See Appendix D for all results.

Fisheries Importance to Countries Strategically Important Only to China:

The average importance of fisheries to countries I calculated as strategically important only to China had a significantly lower average importance ratio than those important only to the US. However, the number was similar to the importance ratio for the countries of shared importance.

This is a significant finding to have such a low importance ratio. I did not expect that result. Five of the nine countries have almost all of the capture importance. But they are balanced out by the countries with whom China shares land borders, for whom capture fisheries are relatively small. See Appendix E for all results.

Fisheries Importance to All 54 Countries Strategically Important to the US

The importance of fisheries to all the countries important to the US is significantly higher than for China. I did not expect this result. This puts added importance for the US on understanding these risks of a potential fisheries collapse. It also sets the stage for China to be able to both add pressure to the US with overfishing while providing for its own needs. See Appendix F for all results.

Fisheries Importance to All 34 Countries Strategically Important to China

This chart shows an increase in importance of fisheries when reincorporating countries of shared interest with the US. The approximately twenty percent increase is accounted for mostly by the maritime nations of Asia that made up most of the top ten

fisheries reliant countries of those important for both the US and China. See Appendix G for all results.

How Do these Compare In Importance with Global Finfish Capture Fisheries?

These fisheries are significant. The top 15 strategically important countries by average capture fishery margin account for 63.2% of the global finfish capture fishery. The other 48 countries account for another 13.99% of the global average total annual catch. See Appendix H for all results.

Table 8: Relative Importance to Global Capture Totals of the Top 15 Strategically Important Countries to US and China as Ranked by 5 Year Average Finfish Capture Fishery (tons, 2014-2018)

Country	5 Year Average (tons, 2014-2018)	Capture - 5 year avg % of strategic country Total 5 year avg (all finfish)	Capture - 5 year avg % of global 5 year average ending 2018 (all finfish)
China	10966386.4	18.14%	**14.00%**
Indonesia	5848617.2	9.68%	**7.47%**
Russian Federation	4466198.2	7.39%	**5.70%**
India	4328300.6	7.16%	**5.53%**
Peru	4203101.4	6.95%	**5.37%**
United States of America	4061766.8	6.72%	**5.19%**
Japan	2727663.8	4.51%	**3.48%**
Viet Nam	2504336.4	4.14%	**3.20%**
Myanmar	2010389.6	3.33%	**2.57%**
Philippines	1886224.2	3.12%	**2.41%**
Bangladesh	1609166.6	2.66%	**2.05%**
Thailand	1319252.2	2.18%	**1.68%**
Malaysia	1270070	2.10%	**1.62%**
Mexico	1223530.2	2.02%	**1.56%**
Korea, Republic of	1072120	1.77%	**1.37%**

VIII. Case Studies for a New Food Security Framework Involving Aquaculture as a Strategic National Security Investment

Can a new framework based on strategic considerations about fish and its role in food security and national security more broadly give the US better balance against China, while maintaining focus on improving food security outcomes?

I compare four frameworks relating to the US' food security efforts to include planning for risks associated with fisheries for the US, and how they relate to our competition with China. I propose three new frameworks to compare with a "no change in policy" scenario.

Table 9: Case Study Scenarios

Case Name	Case Description
Case 1	The US approach to international development and fisheries management remains unchanged. The government has no strategic investment plan for aquaculture in terms of competition with China and being prepared with regard to the potential for capture fisheries collapse.
Case 2	The US provides $4.5 billion in food security funding for capital investments in finfish aquaculture facilities in Feed the Future focus countries strategically important to either the US, China, or both. I selected this arbitrary value because it is approximately what the US spends in one year of operation on overseas expenditures on food programs through Feed the Future and the other seven programs.[47] Countries: Bangladesh, Ethiopia, Kenya, Mali, Nepal, Niger, Nigeria
Case 3	The US provides $4.5 billion in food security funding for capital investments in finfish aquaculture facilities in the countries of shared strategic importance to the US and China, where their per capita fisheries importance ranks in the top 15 highest among the 25 countries strategically important to both. Countries: Bangladesh, Indonesia; Iran (Islamic Rep. of); Japan; Korea, Dem. People's Rep; Korea, Republic of; Malaysia; Myanmar; Philippines; Russian Federation; South Africa; Taiwan Province of China; Thailand; United Kingdom; Viet Nam
Case 4	US invests $4.5 billion to support capital investment in aquaculture projects in the US under the umbrella of food security and national security justifications.[48] In this case, the money would help increase US capacity to produce finfish. Determining the role of government or the method of utilizing that increased US production for trade or aid is beyond the scope of this study.

[47] GAO. "Letter to Congress number GAO-21-47R". November 19, 2020. Accessed online February 26, 2021. https://www.gao.gov/assets/720/710772.pdf

[48] I considered but ultimately decided against a research approach substituting new aquaculture funding in place of Feed the Future efforts. The comparisons are beyond the scope of this paper.

Methodology and Results for Case Study Analyses

Total US aquaculture production in 2017 was worth only approximately $1.2 billion, and US aquaculture production volumes have remained relatively constant at levels significantly less than they were in the early 2000's.[49] US capture fishery production is approximately ten times larger than the aquaculture production, at around 5 million tons annually.[50] However, the capture fisheries employ less than 175,000 people, and the US remains the world's largest importer of fish and fishery products.[51] So although the US is the world's sixth largest capturer of finfish, the industry is a small contributor to the US economy.

The last three case study frameworks would incorporate fisheries risks to a higher role in national security and expand the definition of food security usage, as several of the schools of thought discussed earlier argue it should be. But unlike those angles approaching the issue so far, this paper approaches the issue by assuming that wild capture fisheries may essentially collapse.

If capture fisheries disappeared, what would the security outcomes and opportunity costs of not acting in advance look like? What should the US do now to minimize risks if that were to occur? Would broadening the approach to food security and funding aquaculture investments improve national security outcomes without jeopardizing the mission to improve global food security? Or, would the results be insignificant and signal to policymakers that keeping the status quo might be just as

[49] Food and Agriculture Organization of the United Nations - Fisheries Division. "Fishery and Aquaculture Country Profiles – The United States of America". Accessed May 8, 2021. http://www.fao.org/fishery/facp/USA/en
[50] Ibid.
[51] Ibid.

effective? I evaluated the scenarios and judged the potential for US to invest overseas to supply fish to individual countries or to groups of countries, or to increase US aquaculture production capacity domestically to be supplied as needed. Success is measured for each situation as relative comparison between current country trends and how US investments might alter those.

Case 1:

I calculate projected rates of aquaculture growth for each strategically important country to calculate the projected total aquaculture production volume of each country in 2035, assuming no changes to the rate of growth. I calculate aquaculture per capita in 2035, and measure the difference compared with the capture fishery per capita of 2020.

The results skewed heavily toward countries being unable to replace their capture fishery with aquaculture production should fisheries collapse. Only 22 of 63 countries are projected to have more aquaculture production per capita in 2035 than average capture fishery per capita from 2014-2018 (using 2020 population). Of the 41 who will have less overall fish production, they skewed toward having much larger deficits than the 22 had in gains. See Appendix I for full results.

Appendix J examines the same data but sorts it by the projected volume percentage of total projected aquaculture in 2035. Only 9 countries had more than one percent of the market, each. But they combine to have 92.35 percent of the total aquaculture production of the 63 strategically important countries. The top five alone would account for 82.8 percent of production. China would control nearly 42 percent.

Table 10: Nine Countries Projected to Control the 2035 Aquaculture Market

Country	Country share of strategic country 2035 projected aquaculture totals
China	41.90%
India	19.88%
Indonesia	9.51%
Viet Nam	6.42%
Bangladesh	5.09%
Egypt	4.61%
Myanmar	2.40%
Cambodia	1.51%
Iran (Islamic Rep. of)	1.03%

Case 2:

I analyzed the impact on aquaculture production of providing $4.5 billion on each country separately, and on splitting $4.5 billion equally among the seven countries. A 3600 annual metric ton recirculating facility requires on average approximately $94,824,000 capital investment.[52] I round here to $100 million investment for 4000 metric tons annually per fish farm to create a formula to translate government investment into volume of aquaculture production increase. Investing $4.5 billion should result in complete capital costs for 45 recirculating aquaculture farms for finfish production. Those farms, in total, should produce approximately 180,000 tons of finfish annually.

Investing all of the $4.5 billion for aquaculture in Mali, Niger, or Kenya would create significant return on investment in each country in terms of each country's ability to increase its production of fish. This is because current production is low. Investing in

[52] Bailey, Laura and Vinci, Brian. "Show me the money: Economies of scale for land-based recirculating aquaculture systems." RASTech Magazine. February 4, 2020. Accessed online April 4, 2021 at: www.rastechmagazine.com/show-me-the-money

Nepal and Ethiopia would see marginal returns for the US in this scenario. This investment plan would not make much sense in Nigeria or Bangladesh, as the impact would be marginal on their per capita changes. Sharing the funding equally resulted in significant reductions in impact in those where the results of individually focused investment could have been highly impactful, and does not appear to be a good choice. Policymakers would also have to grapple with the challenges of ensuring the project returns were channeled appropriately in a way that enhances the US interest; this could be a challenging scenario especially in those states significant because of the US counterterrorism efforts there. See Appendix K for full results.

Case 3:

I calculated the impact of US investment in the fifteen countries previously described in the same manner as I did for Case 2. In Case 3, Taiwan, South Korea, Malaysia, and North Korea on paper would get the best return on investment for the US in the scenario of focusing funding on one country. The first three would be particularly good, as they have some of the most significant drops in aquaculture production predictions relative to their capture fishery averages. North Korea's drop in this category was less significant. Regardless, it would not be a candidate for investment due to the nature of the relationship with the US. See Appendix L for full results.

Case 4:

I anticipated Case 4 would make the case that the US should invest in aquaculture development at home where it controls production and could offer a competing market to China should fisheries collapse in the next few decades. I evaluated the projected aquaculture situation in 2035 and found the following:

Table 11: Impact of $4.5 billion invested in Aquaculture Projects Located in the US

	Projected aquaculture production by 2035 given 2018 growth rate	Share of 2035 total aquaculture production by strategically important countries	Additional annual output:45 farms @ $100 million producing 4000 tons annually	Total US Aquaculture Production in 2035 After Investment	Share of otherwise unchanged 2035 total aquaculture production by strategically important countries
US	267805.08	0.32%	180000.00	447805.08	0.53%
China	35427350.15	41.9%			

On one hand, the investment described in Case 4 is significant for the US because it would nearly double the current projected amount of anticipated US aquaculture production. On the other hand, the results show that this amount of investment is rather insignificant. Even doubling US aquaculture production in the US brings it to only one percent of the total projected aquaculture production, while China would control in this scenario approximately 42 percent of global aquaculture production. China's aquaculture value in relative terms to countries of strategic interest is even more striking.

However, it is important to consider that China's domestic market will still demand fish. So the absolute dominance of the market will be tempered somewhat by providing for their own population when capture fisheries have been depleted. However, recall that China's capture fishery importance was, per capita, only in the middle of the pack of the 25 strategic countries. So although there will still be domestic demand for Chinese aquaculture, the size of production opens up even greater opportunities to use their fish production leverage abroad to provide fish to other countries than they can do now as the world's largest capture supplier.

VIII. DISCUSSION

I anticipated Case 4 would show a huge strategic opportunity for the US to be able to better compete with China. But instead of a convincing case to invest, it appears it is a much greater strategic risk that does not look hopeful for US policymakers even if Congress acted quickly. Certainly, not taking any action would exacerbate challenges with China because of the influence they would have when fisheries collapsed. Knowing that they have a long run advantage actually gives Beijing at least one reason to consider taking the risk to continue to push the capture fisheries further, knowing they would stand to gain relative to others – and especially relative to the US. In the interim, the US would face some significant challenges to implement any funding or construction capable of closing the aquaculture gap. Given the scale of investment it would require to even make a significant contribution towards closing the gap, the US may need to explore different options if it is serious about managing the risk of China having control over such an important food source for so much of the world.

With the world's largest population and as a net food importer, China's leadership has a vested interest in ensuring its population has access to food. Few things are more risky to a government's legitimacy than failing to ensure your population has adequate access to food. Food insecurity can turn a population against a government more than other resources. But since that goes for all countries, China can use that as an advantage.

Most literature considers Chinese overfishing from a snapshot of the moment, seeing their fisheries exploitation as a means of cheaply feeding their population from an abundant supply. But this research shows that there could be secondary benefits to China within the umbrella of food security to continuing to exploit the oceans. Many key

countries for China and the US are heavily reliant on fish - and most are not well positioned with aquaculture to meet their demand. Decreased capture fisheries increase China's leverage with those countries as aquaculture becomes relatively more important. This research shows that the US has very little similar leverage, even if undertook a significant funding program of $4.5 billion. Potentially, future research by others may propose a better assessment and generate different results.

Should fisheries actually collapse, the value for aquaculture products will skyrocket accordingly. Economists would suggest that at that time, new players will enter the market and drive down the price. However, capital will be needed to deploy new aquaculture facility construction to replace a capture fisheries system that was essentially infrastructure free. But this research suggests China will control nearly half the existing global market with established production systems if and when that occurred. If Beijing was interested in deterring new entrants to the aquaculture market and maintaining their market share, they would be well positioned to manipulate aquaculture investment markets by pricing their production in already-build infrastructure lower than the cost at which others can justify investment - at least those lower than breakeven costs in lower domestic demand, higher GDP market driven economies like the United States. This is either strategic planning, or good fortune to have developed a robust aquaculture production at massive scale sooner than competitors, or both. But either way, US strategic interests are at stake, because fisheries are important to countries that are very important to the US, and to China. If global fisheries were to collapse, this research finds that those looking for fish for their populations would be absolutely reliant on China to

provide it, or on Beijing to at least to allow fair competition conditions for other countries to enter the market as aquaculture producers.

Limitations:

Certainly, no evaluation of the most important countries can ever account for the importance of all countries adequately. I acknowledge that many approaches will look differently and come up with many different countries than I did.

I recognize that fisheries and food security are just one of dozens of strategic interests at play in the US-China relationship. In no way do I believe that fisheries only will drive the actions of the security relationship. However, this paper shows that fisheries are important to many of the countries evaluated here, and thus, should be considered an important part of the security balance. They are both a risk to be managed, and an opportunity to gain influence.

IX. Conclusion

Is China okay with the potential to completely collapse capture fisheries? Or are they interested in maintaining sustainable harvests for perpetuity? It is beyond the scope of this study to answer that question. But I believe that this research has been beneficial in presenting a new way to analyze countries of importance, and to understand the potential opportunities and limitations for the US to addressing strategic interests and food security simultaneously through investments in aquaculture.

There is much to learn about this topic, and future research can expand on this initial cursory analysis in a variety of ways to further enhance the literature on the subject. What is clear is that food security, as defined by the international development agenda and enshrined in US law via the Global Food Security Act, is limited by the scope

of how we see it. A holistic analysis of threats and opportunities to address those threats has shown that security can be impacted by US action or inaction on food policies, especially in our competition with China.

This research did not find an overwhelmingly beneficial new approach to addressing food security and fisheries risks. The status quo approach to managing fisheries risk should continue in the interim, except that the issue should get more attention and strategic leadership. The current whole of government approach to addressing food and security is too disjointed and too disparately directed to understand how food is related to security. It fails as set up now to see the opportunity costs we face by keeping policies as they are. A broader scope to food security might be helpful - but it should be coupled with the vision and resources to use any new capabilities efficiently and successfully.

Appendices

Appendix A - Calculating the Most Strategically Important Countries for US

Criteria for identifying strategically important countries for US

Category	Explanation	Notes
Nuclear Weapon States	Public information	
Specific states listed in the GAO security risk report as a long-range security threat to US	China, Russia, Iran, North Korea	
10 most important countries - resource dependence	As calculated by New America foundation natural security index	Composite measure of resource dependence for US on countries for the following resources: 24 strategic minerals, 9 commodity metals, energy (coal, gas, oil), and agriculture (coffee, maize, milk, palm, pork, poultry, rice, soy, sugar, wheat)
10 Most important countries - military coordination	As calculated by New America foundation natural security index	Includes combined military exercises, arms imports, and arms exports.
10 Most important countries - Trade volume	As calculated by New America foundation natural security index	
10 Most important countries - Foreign direct investment (one of 4 cultural and soft power)	As calculated by New America foundation natural security index	
Terrorism concerns: States where US is active in combatting terrorism	Defined by the Costs of War project research tracking US activities as follows:	Countries where US had air strikes or ground combat or 127e programs. I did not include the terrorist training exercises as many were likely already included in the new america military relationships situation. Since this includes already Iraq and Afghanistan, I did not include a separate listing for countries where US had troops in conflict since 9/11.
Population		Any country in the top 20 largest population according to the UN is included, if not included already by other categories.
Combined: Foreign government capacity and stability and internal and international migration risk		I created a factor of the product of the Global Fragility Ranking and the population of the country. The top 20 highest combination scores are included.

Note 1: Starting Country List was the 178 identified in the Global Fragility Index. This does not match with the UN population list of countries. I manually pulled the population

data only for those countries listed in the 178 starting countries when assessing population and the fragility * population multiplier.)

Note 2: I used as the starting list of countries the 178 identified in the Global Fragility Index. Taiwan was not included in that list. I included Taiwan as a country of strategic importance for both the US and China. However, I did that after calculating for population and fragility multipliers; those lists were drawn from the data from 178 countries with matching population data from the UN.

Note 3: I considered but ultimately did not use a Western Hemisphere multiplier to increase the fragility x population index scores to rank countries. Those countries do present increase risk of migration to the US over the connected continent; but the migration risk identified by GAO looks at internal and external migration and this would have given too much weight on external migration to the US. External migration in other parts of the world may have a more significant impact on US security than migration to the US border. A second reason is that it would overfactor compared to internal migration and the risks of migration to megacities globally, which I could not account for in this approach. So population and fragility risk is left normalized across the globe.

Appendix B: Calculating the Most Strategically Important Countries for China

Criteria for identifying strategically important countries for China

Category	Explanation	Notes
Nuclear Weapon States	Public information	
10 most important countries - resource dependence	As calculated by New America foundation natural security index	Composite measure of resource dependence for China on countries for the following resources: 24 strategic minerals, 9 commodity metals, energy (coal, gas, oil), and agriculture (coffee, maize, milk, palm, pork, poultry, rice, soy, sugar, wheat)
10 Most important countries - military coordination	As calculated by New America foundation natural security index	Includes combined military exercises, arms imports, and arms exports.
10 Most important countries - Trade volume	As calculated by New America foundation natural security index	
10 Most important countries - Foreign direct investment	As calculated by New America foundation natural security index	
Iran	None	Added as a trade partner based on the March 2021 long term trade deal, although they are not listed in New America's top 10 trading partners.
Territorial disputes	Public information	16 countries with territorial disputes with China, maritime and terrestrial (includes Taiwan, which I added independently for the US)

Note 1: Starting Country List was the 178 identified in the Global Fragility Index. This does not match with the UN population list of countries. I manually pulled the population data only for those countries listed in the 178 starting countries when assessing population and the fragility * population multiplier.)

Note 2: I used as the starting list of countries the 178 identified in the Global Fragility Index. Taiwan was not included in that list. I included Taiwan as a country of strategic importance for both the US and China. However, I did that after calculating for population and fragility multipliers; those lists were drawn from the data from 178 countries with matching population data from the UN.

Note 3: I included all territorial disputes as automatically strategically important for China. However, it is possible that currently marine disputes are actually significantly more important than territorial disputes on land. However, this analysis treats them all equally.

Appendix C - Long-Range Emerging Threats Facing the United States

Source: U.S. Government Accountability Office. "Long-Range Emerging Threats Facing the United States As Identified by Federal Agencies" GAO-19-204SP: Published: Dec 13, 2018.

26 Long-Range Emerging Threats Facing the United States As Identified by Federal Agencies
Chinese Global Expansion» China is marshalling its diplomatic, economic, and military resources to facilitate its rise as a regional and global power. This may challenge U.S. access to air, space, cyberspace, and maritime domains. China's use of cyberspace and electronic warfare could impact various U.S. systems and operations.
Russian Global Expansion» Russia is increasing its capability to challenge the United States across multiple warfare domains, including attempting to launch computer-based directed energy attacks against U.S. military assets. Russia is also increasing its military and political presence in key locations across the world.
Iranian Political and Military Developments» Iran is expanding its influence by increasing the size and capabilities of its network of military, intelligence, and surrogate forces, while increasing economic activities in other areas of the world. Iran will also likely continue to develop its military capabilities, including developing technology that could be used for intercontinental ballistic missiles (ICBM) and improving its offensive cyberspace operations.
North Korean Military Developments» North Korea is developing capabilities to strike North America and its allies with long-range missiles and may produce significant numbers of intercontinental ballistic missiles.
Foreign Government Capacity and Stability» Violent extremist organizations may proliferate in countries that have limited governing capacity and are facing conflict, which may result in a higher risk of terrorist attacks and increased demand for U.S. resources to counter them. Countries in Africa, Latin America, and the Caribbean may experience instability based on conflict, which may lead to humanitarian disasters and government collapses.
Terrorism» Violent ideologies could influence additional individuals to turn to terrorism to achieve their goals across Africa, Asia, and the Middle East. Terrorists could advance their tactics, including building nuclear, biological or chemical weapons, or increase their use of online communications to reach new recruits and disseminate propaganda.
New Alliances and Adversaries» The United States could face challenges from potential new state adversaries and non-state adversaries (e.g., private corporations obtaining resources that could grant them more influence than states).
Information Operations» Adversaries—such as Russia, Iran, and China—may engage in advanced information operations campaigns that use social media, artificial intelligence, and data analytics to undermine the United States and its allies.
Artificial Intelligence (AI)» Adversaries could gain increased access to AI through affordable designs used in the commercial industry, and could apply AI to areas such as weapons and technology.

Quantum Information Science» Quantum communications could enable adversaries to develop secure communications that U.S. personnel would not be able to intercept or decrypt. Quantum computing may allow adversaries to decrypt information, which could enable them to target U.S. personnel and military operations.
Internet of Things (IoT)» The United States may face difficulties protecting networks and data as IoT grows and traditional approaches for security (e.g., encryption) may no longer effectively protect information. Adversaries could also disrupt IoT-enabled critical infrastructure and devices.
Autonomous and Unmanned Systems» Adversaries are developing autonomous capabilities that could recognize faces, understand gestures, and match voices of U.S. personnel, which could compromise U.S. operations. Unmanned ground, underwater, air, and space vehicles may be used for combat and surveillance.
Biotechnology» Actors—which may include state or non-state entities such as violent extremist organizations and transnational criminal organizations—could alter genes or create DNA to modify plants, animals, and humans. Such biotechnologies could be used to enhance the performance of military personnel. The proliferation of synthetic biology—used to create genetic code that does not exist in nature—may increase the number of actors that can create chemical and biological weapons.
Other Emerging Technologies» Actors may gain access to new technologies previously limited to militaries, such as affordable and sophisticated encryption technologies, which would hinder U.S. efforts to monitor terrorist and criminal activities. Other emerging technologies—such as additive manufacturing (i.e., 3D printing)—may be vulnerable to cyber attacks or be used to manufacture restricted materials, such as weapons.
Weapons of Mass Destruction» An increasing number of actors may gain access to these weapons. Adversaries could steal nuclear materials from existing facilities or develop new types of biological weapons using genetic engineering and synthetic biology.
Electronic Warfare» Adversaries are developing electronic attack weapons to target U.S. systems with sensitive electronic components, such as military sensors, communication, navigation, and information systems. These weapons are intended to degrade U.S. capabilities and could restrict situational awareness or may affect military operations.
Hypersonic Weapons» China and Russia are pursuing hypersonic weapons because their speed, altitude, and maneuverability may defeat most missile defense systems, and they may be used to improve long-range conventional and nuclear strike capabilities. There are no existing countermeasures.
Counterspace Weapons» China and Russia are developing anti-satellite weapons to threaten U.S. space operations. China is developing capabilities to conduct large-scale anti-satellite strikes using novel physical, cyber, and electronic warfare means.
Missiles» Adversaries are developing missile technology to attack the United States in novel ways and challenge U.S. missile defense, including conventional and nuclear ICBMs, sea-launched land-attack missiles, and space-based missiles that could orbit the earth.
Intelligence, Surveillance, Reconnaissance (ISR) Platforms» Future advances in AI, sensors, data analytics, and space-based platforms could create an environment of “ubiquitous ISR”, where people and

equipment could be tracked throughout the world in near-real time. China, Russia, Iran, and North Korea are developing multiple ISR platforms.
Aircraft» China and Russia are developing new aircraft, including stealth aircraft, which could fly faster, carry advanced weapons, and achieve greater ranges. Such aircraft could force U.S. aircraft to operate at farther distances and put more U.S. targets at risk.
Undersea Weapons» Russia has made significant advancements in submarine technology and tactics to escape detection by U.S. forces. China is developing underwater acoustic systems that could coordinate swarm attacks—the use of large quantities of simple and expendable assets to overwhelm opponents—among vehicles and provide greater undersea awareness. Adversaries could achieve breakthroughs in anti-submarine warfare—such as using AI to locate U.S. submarines—or attack U.S. undersea infrastructure, which could cripple communications.
Cyber Weapons» Adversaries, such as China, Russia, Iran, and North Korea, may launch cyber attacks against critical U.S. infrastructure (e.g., electric, oil and gas, and nuclear power systems) and military infrastructure (e.g., communications and ISR platforms). Adversaries could also launch cyber attacks on the U.S. health care system, threatening patient safety by disrupting access to medical care. Finally, adversaries are also developing tools to directly attack hardware and embedded components in aviation systems, which can manipulate or destroy data.
Infectious Diseases» New and evolving diseases from the natural environment—exacerbated by changes in climate, the movement of people into cities, and global trade and travel—may become a pandemic. Drug-resistant forms of diseases previously considered treatable could become widespread again.
Climate Change» Extreme weather events—such as hurricanes and megadroughts—could intensify and affect food security, energy resources, and the health care sector. Diminishing permafrost could expand habitats for pathogens that cause disease. The loss of Arctic sea ice could open previously closed sea routes, potentially increasing Russian and Chinese access to the region and challenging the freedom of navigation that the United States currently has.
Internal and International Migration» Governments in megacities (i.e., over 10 million people) across Asia, Latin America, and Africa may not have the capacity to provide adequate resources and infrastructure, and may be vulnerable to natural or man-made disasters. Mass migration events may occur and threaten regional stability, undermine governments, and strain U.S. military and civilian responses.

Appendix D: Importance of Annual Freshwater and Marine Finfish Capture to the 29 Countries Strategically Important Only to the US
(2014-2018 average tons (includes marine, freshwater, and diadromous fishes) : 2020 population estimate)

Country	Annual Average Capture (tons, 2014-2018)	RATIO: Average annual capture: 2020 population	Country	Annual Average Capture (tons, 2014-2018)	RATIO: Average annual capture: 2020 population
Peru	4203101.40	127.47	Turkey	297357.20	3.53
Denmark	733173.00	126.58	Egypt	323025.00	3.16
New Zealand	393947.60	81.70	Kenya	141799.60	2.64
Oman	319258.80	62.51	Congo, Dem. Rep. of the	234742.00	2.62
Ireland	217056.20	43.96	Somalia	28900.00	1.82
Netherlands	378443.80	22.09	Colombia	78892.00	1.55
Canada	431663.40	11.44	Niger	32965.80	1.36
Mexico	1223530.20	9.49	Iraq	37070.80	0.92
Tunisia	93003.40	7.87	Bulgaria	4313.80	0.62
Cameroon	208199.20	7.84	Lebanon	3393.40	0.50
China	10966386.40	7.62	Ethiopia	51761.00	0.45
Yemen	148088.40	4.97	Syrian Arab Republic	4236.60	0.24
Mali	94314.60	4.66	Afghanistan	1860.00	0.05
Libya	27090.20	3.94	Luxembourg	0.00	0.00
Nigeria	749017.40	3.63	**AVERAGES**	**738847.97**	**18.80**

Appendix E: Importance of Annual Freshwater and Marine Finfish Capture to the 9 Countries Strategically Important Only to China
(2014-2018 average tons (includes marine, freshwater, and diadromous fishes) : 2020 population estimate)

Country	Annual Average Capture (tons, 2014-2018)	RATIO: Average annual capture: 2020 population
Cambodia	609067.60	36.43
Brunei Darussalam	7949.20	18.19
Angola	473281.00	14.40
United States of America	4061766.80	12.27
Lao People's Dem. Rep.	67117.40	9.22
Turkmenistan	15000.00	2.49
Nepal	21514.00	0.74
Bhutan	11.00	0.01
Mongolia	34.80	0.01
AVERAGES	**583971.31**	**10.42**

Appendix F: Importance of Annual Freshwater and Marine Finfish Capture to All 54 Countries Strategically Important to the US
(2014-2018 average tons (includes marine, freshwater, and diadromous fishes) : 2020 population estimate)

Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita (2020 population, per 1000)	Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita (2020 population, per 1000)
Peru	4203101.40	127.47	Australia	119998.40	4.71
Denmark	733173.00	126.58	Mali	94314.60	4.66
New Zealand	393947.60	81.70	Libya	27090.20	3.94
Oman	319258.80	62.51	Nigeria	749017.40	3.63
Ireland	217056.20	43.96	Turkey	297357.20	3.53
Malaysia	1270070.00	39.24	Egypt	323025.00	3.16
Myanmar	2010389.60	36.95	India	4328300.60	3.14
Russian Federation	4466198.20	30.60	Brazil	657698.60	3.09
Taiwan Province of China	724707.20	30.43	Germany	241910.60	2.89
Viet Nam	2504336.40	25.73	Kenya	141799.60	2.64
Netherlands	378443.80	22.09	Congo, Dem. Rep. of the	234742.00	2.62
Japan	2727663.80	21.57	Pakistan	471161.00	2.13
Indonesia	5848617.20	21.38	Somalia	28900.00	1.82
Korea, Republic of	1072120.00	20.91	Saudi Arabia	54133.60	1.55
Thailand	1319252.20	18.90	Colombia	78892.00	1.55
Philippines	1886224.20	17.21	Niger	32965.80	1.36
Canada	431663.40	11.44	Iraq	37070.80	0.92
Bangladesh	1609166.60	9.77	Bulgaria	4313.80	0.62
Mexico	1223530.20	9.49	Lebanon	3393.40	0.50
South Africa	561219.40	9.46	Ethiopia	51761.00	0.45
United Kingdom	574740.00	8.47	Israel and Palestine	4369.00	0.32
Iran (Islamic Rep. of)	693005.60	8.25	Syrian Arab Republic	4236.60	0.24
Tunisia	93003.40	7.87	Switzerland	1861.40	0.22
Cameroon	208199.20	7.84	Singapore	877.00	0.15
China	**10966386.40**	**7.62**	Afghanistan	1860.00	0.05
Korea, Dem. People's Rep	187086.00	7.26	Luxembourg	0.00	0.00
France	425663.00	6.52	**AVERAGES**	**1021988.163**	**16.22**
Yemen	148088.40	4.97			

Appendix G: Importance of Annual Freshwater and Marine Finfish Capture to All 34 Countries Strategically Important to China
(2014-2018 average tons (includes marine, freshwater, and diadromous fishes):2020 population estimate)

Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita: (2020 population, per 1000)	Country	Annual Average Capture (tons, 2014-2018)	Average annual capture per capita: (2020 population, per 1000)
Malaysia	1270070.00	39.24	Iran (Islamic Rep. of)	693005.60	8.25
Myanmar	2010389.60	36.95	Korea, Dem. People's Rep	187086.00	7.26
Cambodia	609067.60	36.43	France	425663.00	6.52
Russian Federation	4466198.20	30.60	Australia	119998.40	4.71
Taiwan Province of China	724707.20	30.43	India	4328300.60	3.14
Viet Nam	2504336.40	25.73	Brazil	657698.60	3.09
Japan	2727663.80	21.57	Germany	241910.60	2.89
Indonesia	5848617.20	21.38	Turkmenistan	15000.00	2.49
Korea, Republic of	1072120.00	20.91	Pakistan	471161.00	2.13
Thailand	1319252.20	18.90	Saudi Arabia	54133.60	1.55
Brunei Darussalam	7949.20	18.19	Nepal	21514.00	0.74
Philippines	1886224.20	17.21	Israel and Palestine	4369.00	0.32
Angola	473281.00	14.40	Switzerland	1861.40	0.22
United States of America	4061766.80	12.27	Singapore	877.00	0.15
Bangladesh	1609166.60	9.77	Bhutan	11.00	0.01
South Africa	561219.40	9.46	Mongolia	34.80	0.01
Lao People's Dem. Rep.	67117.40	9.22	**AVERAGES**	**1147544.45**	**12.49**

Appendix H - Relative Importance to Global Finfish Capture

Country	5 Year Average (tons, 2014-2018)	Capture - 5 year avg % of strategic country Total 5 year avg (all finfish)	Capture -5 year avg% of global 5 year average ending 2018 (all finfish)	Country	5 Year Average (tons, 2014-2018)	Capture - 5 year avg % of strategic country Total 5 year avg (all finfish)	Capture - 5 year avg% of global 5 year average ending 2018 (all finfish)
China	10966386.4	18.14%	14.00%	Germany	241910.6	0.40%	0.31%
Indonesia	5848617.2	9.68%	7.47%	Congo, Dem. Rep. of the	234742	0.39%	0.30%
Russian Federation	4466198.2	7.39%	5.70%	Ireland	217056.2	0.36%	0.28%
India	4328300.6	7.16%	5.53%	Cameroon	208199.2	0.34%	0.27%
Peru	4203101.4	6.95%	5.37%	Korea, Dem. People's Rep	187086	0.31%	0.24%
United States of America	4061766.8	6.72%	5.19%	Yemen	148088.4	0.25%	0.19%
Japan	2727663.8	4.51%	3.48%	Kenya	141799.6	0.23%	0.18%
Viet Nam	2504336.4	4.14%	3.20%	Australia	119998.4	0.20%	0.15%
Myanmar	2010389.6	3.33%	2.57%	Mali	94314.6	0.16%	0.12%
Philippines	1886224.2	3.12%	2.41%	Tunisia	93003.4	0.15%	0.12%
Bangladesh	1609166.6	2.66%	2.05%	Colombia	78892	0.13%	0.10%
Thailand	1319252.2	2.18%	1.68%	Lao People's Dem. Rep.	67117.4	0.11%	0.09%
Malaysia	1270070	2.10%	1.62%	Saudi Arabia	54133.6	0.09%	0.07%
Mexico	1223530.2	2.02%	1.56%	Ethiopia	51761	0.09%	0.07%
Korea, Republic of	1072120	1.77%	1.37%	Iraq	37070.8	0.06%	0.05%
Nigeria	749017.4	1.24%	0.96%	Niger	32965.8	0.05%	0.04%
Denmark	733173	1.21%	0.94%	Somalia	28900	0.05%	0.04%

Taiwan Province of China	724707.2	1.20%	0.93%	Libya	27090.2	0.04%	0.03%
Iran (Islamic Rep. of)	693005.6	1.15%	0.88%	Nepal	21514	0.04%	0.03%
Brazil	657698.6	1.09%	0.84%	Turkmenistan	15000	0.02%	0.02%
Cambodia	609067.6	1.01%	0.78%	Brunei Darussalam	7949.2	0.01%	0.01%
United Kingdom	574740	0.95%	0.73%	Israel and Palestine*	4369	0.01%	0.01%
South Africa	561219.4	0.93%	0.72%	Bulgaria	4313.8	0.01%	0.01%
Angola	473281	0.78%	0.60%	Syrian Arab Relic	4236.6	0.01%	0.01%
Pakistan	471161	0.78%	0.60%	Lebanon	3393.4	0.01%	0.00%
Canada	431663.4	0.71%	0.55%	Switzerland	1861.4	0.00%	0.00%
France	425663	0.70%	0.54%	Afghanistan	1860	0.00%	0.00%
New Zealand	393947.6	0.65%	0.50%	Singapore	877	0.00%	0.00%
Netherlands	378443.8	0.63%	0.48%	Mongolia	34.8	0.00%	0.00%
Egypt	323025	0.53%	0.41%	Bhutan	11	0.00%	0.00%
Oman	319258.8	0.53%	0.41%	Luxembourg	0	0	0
Turkey	297357.2	0.49%	0.38%				

Appendix I - Case 1: 2035 Projections of Aquaculture and Fisheries for All Strategically Important Countries, Sorted by Net Difference in Per Capita Outcomes Between 2018 Capture Fishery Averages and 2035 Aquaculture Projections

Case 1: status quo - no change in growth rates and no investment for aquaculture capital

Country	5 Year Average	Capture - 5 year avg % of strategic country Total 5 year avg (all finfish)	Capture - 5 year avg% of global 5 year average ending 2018 (all finfish)	Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Aquaculture Growth Rate From 2014-2018	Projected aquaculture production by 2035 given 2018 growth rate (tons)	Projected aquaculture volume per capita if no investment (tons, 2035 population)	Difference: 2035 aquaculture volume per capita - Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Country share of strategic country 2035 projected aquaculture totals
Peru	4203101.4	6.95%	5.37%	127.47	0.07	207158.06	5.54	-121.93	0.24%
Denmark	733173	1.21%	0.94%	126.58	0.00	30115.32	4.95	-121.63	0.04%
New Zealand	393947.6	0.65%	0.50%	81.70	0.07	48999.54	9.22	-72.48	0.06%
Oman	319258.8	0.53%	0.41%	62.51	0.20	9696.24	1.56	-60.95	0.01%
Ireland	217056.2	0.36%	0.28%	43.96	0.04	23057.57	4.29	-39.66	0.03%
Malaysia	1270070	2.10%	1.62%	39.24	-0.02	102269.02	2.72	-36.52	0.12%
Russian Federation	4466198.2	7.39%	5.70%	30.60	0.03	335904.52	2.38	-28.22	0.40%
Taiwan Province of China	724707.2	1.20%	0.93%	30.43	-0.03	117840.27	4.93	-25.50	0.14%
Netherlands	378443.8	0.63%	0.48%	22.09	0.03	11393.88	0.65	-21.44	0.01%
Japan	2727663.8	4.51%	3.48%	21.57	0.00	302305.56	2.58	-18.99	0.36%
Korea, Republic of	1072120	1.77%	1.37%	20.91	0.00	110592.91	2.18	-18.73	0.13%
Angola	473281	0.78%	0.60%	14.40	0.17	23563.09	0.45	-13.95	0.03%

Thailand	1319252.2	2.18 %	1.68%	18.90	0.00	397603.61	5.69	-13.21	0.47%
United States of America	4061766.8	6.72 %	5.19%	12.27	0.01	267805.08	0.75	-11.52	0.32%
Philippines	1886224.2	3.12 %	2.41%	17.21	0.01	755966.17	5.81	-11.40	0.89%
Brunei Darussalam	7949.2	0.01 %	0.01%	18.19	0.14	3500.95	7.26	-10.93	0.00%
South Africa	561219.4	0.93 %	0.72%	9.46	0.00	2165.61	0.03	-9.43	0.00%
Mexico	1223530.2	2.02 %	1.56%	9.49	-0.03	45521.60	0.31	-9.18	0.05%
Cameroon	208199.2	0.34 %	0.27%	7.84	0.07	6867.92	0.18	-7.66	0.01%
United Kingdom	574740	0.95 %	0.73%	8.47	-0.01	142067.79	1.99	-6.48	0.17%
France	425663	0.70 %	0.54%	6.52	-0.02	27598.39	0.41	-6.11	0.03%
Yemen	148088.4	0.25 %	0.19%	4.97	0.00	0.00	0.00	-4.97	0.00%
Mali	94314.6	0.16 %	0.12%	4.66	0.10	20000.66	0.65	-4.01	0.02%
Libya	27090.2	0.04 %	0.03%	3.94	0.00	10.00	0.00	-3.94	0.00%
Korea, Dem. People's Rep	187086	0.31 %	0.24%	7.26	0.12	97964.33	3.65	-3.61	0.12%
Myanmar	2010389.6	3.33 %	2.57%	36.95	0.04	2028436.14	33.77	-3.18	2.40%
Nigeria	749017.4	1.24 %	0.96%	3.63	-0.02	224830.86	0.76	-2.87	0.27%
Germany	241910.6	0.40 %	0.31%	2.89	-0.03	11558.14	0.14	-2.75	0.01%
Kenya	141799.6	0.23 %	0.18%	2.64	-0.12	1766.05	0.02	-2.61	0.00%
Congo, Dem. Rep. of the	234742	0.39 %	0.30%	2.62	0.02	4522.97	0.03	-2.59	0.01%
Turkmenistan	15000	0.02 %	0.02%	2.49	0.11	440.60	0.06	-2.43	0.00%
Somalia	28900	0.05 %	0.04%	1.82	0.00	0.00	0.00	-1.82	0.00%
Canada	431663.4	0.71 %	0.55%	11.44	0.06	419258.15	9.93	-1.51	0.50%
Pakistan	471161	0.78 %	0.60%	2.13	0.01	199216.02	0.70	-1.43	0.24%
Niger	32965.8	0.05 %	0.04%	1.36	0.01	428.68	0.01	-1.35	0.00%
Iraq	37070.8	0.06 %	0.05%	0.92	-0.01	22878.86	0.41	-0.51	0.03%
Saudi Arabia	54133.6	0.09 %	0.07%	1.55	0.06	44935.92	1.09	-0.46	0.05%
Ethiopia	51761	0.09 %	0.07%	0.45	0.10	780.96	0.00	-0.45	0.00%
Lebanon	3393.4	0.01 %	0.00%	0.50	-0.02	727.10	0.12	-0.38	0.00%

Syrian Arab Republic	4236.6	0.01 %	0.01%	0.24	-0.06	893.13	0.03	-0.21	0.00%
Mongolia	34.8	0.00 %	0.00%	0.01	0.00	0.00	0.00	-0.01	0.00%
Luxembourg	0			0.00	0.00	0.00	0.00	0.00	0.00%
Switzerland	1861.4	0.00 %	0.00%	0.22	0.02	2329.65	0.25	0.03	0.00%
Tunisia	93003.4	0.15 %	0.12%	7.87	0.10	103888.07	7.94	0.07	0.12%
Brazil	657698.6	1.09 %	0.84%	3.09	0.02	736379.24	3.24	0.15	0.87%
Afghanistan	1860	0.00 %	0.00%	0.05	0.08	29531.84	0.56	0.51	0.03%
Israel and Palestine*	4369	0.01 %	0.01%	0.32	-0.03	17080.86	0.97	0.65	0.02%
Singapore	877	0.00 %	0.00%	0.15	0.02	6025.80	0.94	0.79	0.01%
Iran (Islamic Rep. of)	693005.6	1.15 %	0.88%	8.25	0.05	870543.67	9.08	0.83	1.03%
Bhutan	11	0.00 %	0.00%	0.01	0.08	776.82	0.90	0.88	0.00%
Australia	119998.4	0.20 %	0.15%	4.71	0.06	220959.25	7.51	2.81	0.26%
Lao People's Dem. Rep.	67117.4	0.11 %	0.09%	9.22	0.00	107475.81	12.46	3.24	0.13%
Nepal	21514	0.04 %	0.03%	0.74	0.05	141678.00	4.13	3.39	0.17%
Turkey	297357.2	0.49 %	0.38%	3.53	0.05	703272.97	7.66	4.13	0.83%
Indonesia	5848617.2	9.68 %	7.47%	21.38	0.04	8042491.75	25.96	4.58	9.51%
Colombia	78892	0.13 %	0.10%	1.55	0.06	343046.46	6.29	4.74	0.41%
Bulgaria	4313.8	0.01 %	0.01%	0.62	0.07	47130.50	7.67	7.05	0.06%
India	4328300.6	7.16 %	5.53%	3.14	0.06	16806288.98	10.82	7.68	19.88%
Bangladesh	1609166.6	2.66 %	2.05%	9.77	0.04	4303211.67	23.34	13.57	5.09%
China	10966386.4	18.14 %	14.00%	7.62	0.02	35427350.15	24.25	16.63	41.90%
Viet Nam	2504336.4	4.14 %	3.20%	25.73	0.04	5425111.02	51.04	25.31	6.42%
Egypt	323025	0.53 %	0.41%	3.16	0.06	3896280.60	29.89	26.74	4.61%
Cambodia	609067.6	1.01 %	0.78%	36.43	0.10	1278288.79	64.93	28.50	1.51%
Grand total - strategic countries	60443102.6					84559783.54	11.57	11.57	100.00%

Appendix J: Case 1: 2035 Projections of Aquaculture and Fisheries for All Strategically Important Countries, Sorted by Descending Percentage Shares of Total 2035 Aquaculture Projection for All Strategically Important Countries

Case 1: status quo - no change in growth rates and no investment for aquaculture capital

Country	5 Year Average	Capture - 5 year avg % of strategic country Total 5 year avg (all finfish)	Capture -5 year avg% of global 5 year average ending 2018 (all finfish)	Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Aquaculture Growth Rate From 2014-2018	Projected aquaculture production by 2035 given 2018 growth rate (tons)	Projected aquaculture volume per capita if no investment (tons, 2035 population)	Difference: 2035 aquaculture volume per capita - Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Country share of strategic country 2035 projected aquaculture totals
China	10966386.4	18.14%	14.00%	7.62	0.02	35427350.15	24.25	16.63	41.90%
India	4328300.6	7.16%	5.53%	3.14	0.06	16806288.98	10.82	7.68	19.88%
Indonesia	5848617.2	9.68%	7.47%	21.38	0.04	8042491.75	25.96	4.58	9.51%
Viet Nam	2504336.4	4.14%	3.20%	25.73	0.04	5425111.02	51.04	25.31	6.42%
Bangladesh	1609166.6	2.66%	2.05%	9.77	0.04	4303211.67	23.34	13.57	5.09%
Egypt	323025	0.53%	0.41%	3.16	0.06	3896280.60	29.89	26.74	4.61%
Myanmar	2010389.6	3.33%	2.57%	36.95	0.04	2028436.14	33.77	-3.18	2.40%
Cambodia	609067.6	1.01%	0.78%	36.43	0.10	1278288.79	64.93	28.50	1.51%
Iran (Islamic Rep. of)	693005.6	1.15%	0.88%	8.25	0.05	870543.67	9.08	0.83	1.03%
Philippines	1886224.2	3.12%	2.41%	17.21	0.01	755966.17	5.81	-11.40	0.89%
Brazil	657698.6	1.09%	0.84%	3.09	0.02	736379.24	3.24	0.15	0.87%
Turkey	297357.2	0.49%	0.38%	3.53	0.05	703272.97	7.66	4.13	0.83%
Canada	431663.4	0.71%	0.55%	11.44	0.06	419258.15	9.93	-1.51	0.50%
Thailand	1319252.2	2.18%	1.68%	18.90	0.00	397603.61	5.69	-13.21	0.47%
Colombia	78892	0.13%	0.10%	1.55	0.06	343046.46	6.29	4.74	0.41%
Russian Federation	4466198.2	7.39%	5.70%	30.60	0.03	335904.52	2.38	-28.22	0.40%
Japan	2727663.8	4.51%	3.48%	21.57	0.00	302305.56	2.58	-18.99	0.36%
United States of America	4061766.8	6.72%	5.19%	12.27	0.01	267805.08	0.75	-11.52	0.32%
Nigeria	749017.4	1.24%	0.96%	3.63	-0.02	224830.86	0.76	-2.87	0.27%
Australia	119998.4	0.20%	0.15%	4.71	0.06	220959.25	7.51	2.81	0.26%
Peru	4203101.4	6.95%	5.37%	127.47	0.07	207158.06	5.54	-121.93	0.24%
Pakistan	471161	0.78%	0.60%	2.13	0.01	199216.02	0.70	-1.43	0.24%

United Kingdom	574740	0.95%	0.73%	8.47	-0.01	142067.79	1.99	-6.48	0.17%
Nepal	21514	0.04%	0.03%	0.74	0.05	141678.00	4.13	3.39	0.17%
Taiwan Province of China	724707.2	1.20%	0.93%	30.43	-0.03	117840.27	4.93	-25.50	0.14%
Korea, Republic of	1072120	1.77%	1.37%	20.91	0.00	110592.91	2.18	-18.73	0.13%
Lao People's Dem. Rep.	67117.4	0.11%	0.09%	9.22	0.00	107475.81	12.46	3.24	0.13%
Tunisia	93003.4	0.15%	0.12%	7.87	0.10	103888.07	7.94	0.07	0.12%
Malaysia	1270070	2.10%	1.62%	39.24	-0.02	102269.02	2.72	-36.52	0.12%
Korea, Dem. People's Rep	187086	0.31%	0.24%	7.26	0.12	97964.33	3.65	-3.61	0.12%
New Zealand	393947.6	0.65%	0.50%	81.70	0.07	48999.54	9.22	-72.48	0.06%
Bulgaria	4313.8	0.01%	0.01%	0.62	0.07	47130.50	7.67	7.05	0.06%
Mexico	1223530.2	2.02%	1.56%	9.49	-0.03	45521.60	0.31	-9.18	0.05%
Saudi Arabia	54133.6	0.09%	0.07%	1.55	0.06	44935.92	1.09	-0.46	0.05%
Denmark	733173	1.21%	0.94%	126.58	0.00	30115.32	4.95	-121.63	0.04%
Afghanistan	1860	0.00%	0.00%	0.05	0.08	29531.84	0.56	0.51	0.03%
France	425663	0.70%	0.54%	6.52	-0.02	27598.39	0.41	-6.11	0.03%
Angola	473281	0.78%	0.60%	14.40	0.17	23563.09	0.45	-13.95	0.03%
Ireland	217056.2	0.36%	0.28%	43.96	0.04	23057.57	4.29	-39.66	0.03%
Iraq	37070.8	0.06%	0.05%	0.92	-0.01	22878.86	0.41	-0.51	0.03%
Mali	94314.6	0.16%	0.12%	4.66	0.10	20000.66	0.65	-4.01	0.02%
Israel and Palestine*	4369	0.01%	0.01%	0.32	-0.03	17080.86	0.97	0.65	0.02%
Germany	241910.6	0.40%	0.31%	2.89	-0.03	11558.14	0.14	-2.75	0.01%
Netherlands	378443.8	0.63%	0.48%	22.09	0.03	11393.88	0.65	-21.44	0.01%
Oman	319258.8	0.53%	0.41%	62.51	0.20	9696.24	1.56	-60.95	0.01%
Cameroon	208199.2	0.34%	0.27%	7.84	0.07	6867.92	0.18	-7.66	0.01%
Singapore	877	0.00%	0.00%	0.15	0.02	6025.80	0.94	0.79	0.01%
Congo, Dem. Rep. of the	234742	0.39%	0.30%	2.62	0.02	4522.97	0.03	-2.59	0.01%
Brunei Darussalam	7949.2	0.01%	0.01%	18.19	0.14	3500.95	7.26	-10.93	0.00%
Switzerland	1861.4	0.00%	0.00%	0.22	0.02	2329.65	0.25	0.03	0.00%
South Africa	561219.4	0.93%	0.72%	9.46	0.00	2165.61	0.03	-9.43	0.00%
Kenya	141799.6	0.23%	0.18%	2.64	-0.12	1766.05	0.02	-2.61	0.00%

Syrian Arab Republic	4236.6	0.01%	0.01%	0.24	-0.06	893.13	0.03	-0.21	0.00%
Ethiopia	51761	0.09%	0.07%	0.45	0.10	780.96	0.00	-0.45	0.00%
Bhutan	11	0.00%	0.00%	0.01	0.08	776.82	0.90	0.88	0.00%
Lebanon	3393.4	0.01%	0.00%	0.50	-0.02	727.10	0.12	-0.38	0.00%
Turkmenistan	15000	0.02%	0.02%	2.49	0.11	440.60	0.06	-2.43	0.00%
Niger	32965.8	0.05%	0.04%	1.36	0.01	428.68	0.01	-1.35	0.00%
Libya	27090.2	0.04%	0.03%	3.94	0.00	10.00	0.00	-3.94	0.00%
Luxembourg	0			0.00	0.00	0.00	0.00	0.00	0.00%
Mongolia	34.8	0.00%	0.00%	0.01	0.00	0.00	0.00	-0.01	0.00%
Somalia	28900	0.05%	0.04%	1.82	0.00	0.00	0.00	-1.82	0.00%
Yemen	148088.4	0.25%	0.19%	4.97	0.00	0.00	0.00	-4.97	0.00%
Grand total - strategic countries	60443102.6					84559783.54	11.57	11.57	100.00%

Appendix K - Case 2 Analysis Results

Case 2: all US investment in FtF countries strategically important to either, US, China, or Both (Bangladesh, Ethiopia, Kenya, Mali, Nepal, Niger, Nigeria), either single country focus spending or shared spending

Country	Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Projected aquaculture volume per capita if no investment (tons, 2035 population)	Projected 2035 production if US investment in only country (all in one country) (adds 180,000 tons)	Projected 2035 per capita total production with US investment in only country (all in one country) (adds 180,000 tons)	Difference in per capita between country specific investment and no investment	Projected 2035 production if US investment is shared across 7 countries (adds 25,714.2857 to each)	Projected 2035 per capita total production if US investment is shared across 7 countries (adds 25,714.2857 to each, 2035 population)	Difference in per capita between shared investment and no investment
Mali	4.66	0.65	200000.66	6.49	5.84	45714.95	1.48	0.83
Nepal	0.74	4.13	321678.00	9.38	5.25	167392.28	4.88	0.75
Niger	1.36	0.01	180428.68	4.36	4.35	26142.97	0.63	0.62
Kenya	2.64	0.02	181766.05	2.49	2.46	27480.33	0.38	0.35
Ethiopia	0.45	0.00	180780.96	1.13	1.12	26495.25	0.17	0.16
Bangladesh	9.77	23.34	4483211.67	24.32	0.98	4328925.96	23.48	0.14
Nigeria	3.63	0.76	404830.86	1.37	0.61	250545.14	0.85	0.09

Appendix L - Case 3 Analysis Results

Country	Difference: 2035 aquaculture volume per capita - Average annual capture fishery per capita (2014-2018 average tons, 2020 population)	Country share of strategic country 2035 projected aquaculture totals	Projected 2035 production if US investment in only country (all in one country) (adds 180,000 tons)	Projected 2035 per capita total production with US investment in only country (all in one country) (adds 180,000 tons)	Difference in per capita between country specific investment and no investment	Projected 2035 production if US investment is shared across 15 countries (adds 12,000 to each)	Projected 2035 per capita total production if US investment is shared across 15 countries (adds 12,000 to each, 2035 population)	Difference in per capita between shared investment and no investment
Taiwan Province of China	-25.50	0.14%	297840.27	12.46	7.53	129840.27	5.43	0.50
Korea, Dem. People's Rep	-3.61	0.12%	277964.33	10.36	6.71	109964.33	4.10	0.45
Malaysia	-36.52	0.12%	282269.02	7.51	4.79	114269.02	3.04	0.32
Korea, Republic of	-18.73	0.13%	290592.91	5.73	3.55	122592.91	2.42	0.24
Myanmar	-3.18	2.40%	2208436.14	36.77	3.00	2040436.14	33.97	0.20
South Africa	-9.43	0.00%	182165.61	2.65	2.62	14165.61	0.21	0.17
Thailand	-13.21	0.47%	577603.61	8.26	2.58	409603.61	5.86	0.17
United Kingdom	-6.48	0.17%	322067.79	4.50	2.52	154067.79	2.15	0.17
Iran (Islamic Rep. of)	0.83	1.03%	1050543.67	10.96	1.88	882543.67	9.21	0.13
Viet Nam	25.31	6.42%	5605111.02	52.73	1.69	5437111.02	51.15	0.11
Japan	-18.99	0.36%	482305.56	4.12	1.54	314305.56	2.68	0.10
Philippines	-11.40	0.89%	935966.17	7.20	1.38	767966.17	5.91	0.09
Russian Federation	-28.22	0.40%	515904.52	3.66	1.28	347904.52	2.47	0.09
Bangladesh	13.57	5.09%	4483211.67	24.32	0.98	4315211.67	23.40	0.07
Indonesia	4.58	9.51%	8222491.75	26.54	0.58	8054491.75	26.00	0.04
United States of America	-11.52	0.32%						
China	16.63	41.90%						

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Curriculum Vita

Ryan Haerer works and writes primarily on national security, energy, agriculture, resources, and the environment. Originally from Ohio, he is a veteran of the US Army and the US Environmental Protection Agency. He now lives with his family on the east coast.